50th Anniversary Edition
# of the History for

Defence
Research
Establishment
Ottawa

1941 1991

Compiled and edited by
Jim Norman & Rita Crow

DREO Special Edition
March 1992

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A HISTORY OF
THE DEFENCE RESEARCH
ESTABLISHMENT OTTAWA
1941-1991

Compiled and Edited

By

Jim Norman and Rita Crow

Protective Sciences Division
DREO

March 1992
Ottawa

EDITOR'S FOREWORD

50 This document, while it presents the history of the Defence Research Establishment Ottawa (DREO) from its earliest times to the present, concentrates on the history of DREO at Shirleys Bay. Harry Sheffer, the only person to be simultaneously Chief, Director, and Section Head at DREO, gave us his reminiscences of these early times but added the comment that his most interesting ones could not be committed to paper, however he did provide us with some of the printable ones. Miles Benson, who predated DREO and CWL, offered to fill us in on the earliest history, an offer which we accepted gratefully.

Each Division which now makes up DREO was asked to contribute a chapter, as were Divisions and Special Project groups which were part of DREO's past. DREO's present technical programs include some that were resident at DRTE/CRC for many years: the Electronics, Electronic Warfare, and Radar programs; therefore, we have included a short account of the early history of DRTE as well.

In some instances, we have been furnished two versions of the same events by different groups involved, each presenting their own views, and this had led to some repetition wherever we have chosen to include both versions.

It has been our pleasure to put together this history of DREO. Our thanks go to those who gave us their recollections of the history, in particular, to the late Dr. T.E. (Tommy) King who gave us, over many years, a distillation of DREO's earlier programs. Reminiscences from Bob Heggie, Bob Bannard, Gerry Nagy, Bill Armstrong, Ron Haines, Jim Wheat, Ian Lindsay, George Grant, Oscar Chambers, Ken Haley, Vernon Smith, Oscar Sandoz and Lloyd Wilson also were gratefully received. Finally we also would like to thank all those authors who contributed to the individual histories: Miles Benson, Bert Bridgewater, Charlie Clifford, Ernie Criddle, Dave DiFillipo, Jay Greenblatt, Bill Hindson, Don Judd, Roy McPherson, LeRoy Nelms, Harry Nash, Bill Osborne, Joan Ross, Jim Salt, Harry Sheffer, Parr Tate, Malcolm Vant and Mike Vinnins. With much assistance on the part of all our colleagues both past and present, we have assembled this story. We think that we have got it right.

The editors would like to extend a special thanks and express their appreciation to Brenda Bourgoin who typed the manuscript and carried out the nearly-endless revisions during the writing of this history.

Jim Norman and Rita M. Crow
Ottawa 1992

FOOTNOTES TO HISTORY

THE SHIRLEYS-BAY SITE NAME

There is confusion surrounding the name of the site of DREO and CRC, and the following has been provided by The Canadian Permanent Committee on Geographical Names. The land presently occupied by CRC and DREO (the Site) originally was deeded to a Thomas Shirley, the bay on the Ottawa River became known as "Shirley's Bay", and the surrounding land area came to be called "the Shirley's Bay Area". During WWII, the area came to be known as "Shirley Bay". This name continued in use at least until 1956 and is used throughout the official history of DRB "A History of the Defence Research Board of Canada" by Capt. D.J. Goodspeed of the Army Historical Section, a forerunner of the present-day Canadian Forces Directorate of History. It then was supplanted by the older Shirley's Bay name (indeed, the "Ottawa Citizen" had always used this name, and continues to do so to this day). In 1962, the Permanent Committee assigned "Shirleys Bay" as the official place name, in line with its policy decision to delete apostrophes or other punctuation in Canadian Places Names. This Shirleys Bay name is now used on all official maps and in all official references.

EDITOR'S NOTE ADDED IN PROOF

On June 29th, 1992, CRAD announced the disbanding of the Protective Sciences Division, to take place over the next two years. In general, Chemical Protection Section and its Program and those elements of the Environmental Protection Section concerned with chemical defence are to be transferred to DRES. Environmental Protection Section elements concerned with non-chemical defence programs are to be relocated to DCIEM.

This completes the phasing-out of the Chemical Defence Program at DREO, first announced in 1986 and implemented by disbanding the Chemical Detection and Decontamination Section and transferring "Detection" elements to DRES in 1986 and "Decontamination" elements in 1988.

With this final change, DREO's connection with its original mandate and the program which occupied much of its resources for the past fifty-six years, has been broken. The current DREO mandate is to operate the Department's R&D programs on electronic warfare, electronic defences, and radar.

Jim Norman, 1992

TABLE OF CONTENTS

EDITOR'S FOREWORD - by Jim Norman and Rita Crow iii

A FOOTNOTE TO HISTORY iv

- THE SHIRLEYS BAY SITE NAME iv
- EDITOR'S NOTE ADDED IN PROOF - by Jim Norman iv

HISTORICAL OVERVIEWS 1

- DREO - by Jim Norman 3
- DRTE - From WWII to CRC - by LeRoy Nelms and Bill Hindson 9
- Personal Reminiscences of Early Days - by Harry Sheffer 11

SETTING THE STAGE 13

- Prologue - The Pre-WWII Years and NRC - by Miles Benson 15
- The War Years - by Miles Benson 17
- Postwar - DRB, DRCL, and the Move to Shirleys Bay - by Jim Norman 23

THE NUCLEAR, CHEMICAL, AND BIOLOGICAL DEFENCE PROGRAMS 25

- Overview - by Jim Norman 27
- Nuclear Defence Research at DREO - 1953 to 1982 - by Parr Tate 29
- The Chemical Defence Program - 1941 to 1982 - by Jim Norman 37
- Protection from the Environment - 1960-1977 - by Harry Nash and Rita Crow 55
  - "D" Wing 1960-1969 - by Harry Nash 55
  - The Exploratory Studies Group and the Environmental Protection Section - 1969-1977 - by Rita Crow 58
- The Protective Sciences Division - by Charlie Clifford 61
- The Special Study on "Yellow Rain" - by Jim Norman and Garfield Purdon 71

THE ELECTRONICS PROGRAMS 73

- DRTE and Canada's Leap into Space: The Early Canadian Satellite Program - by LeRoy Nelms 75
- The Defence Electronics Division - by LeRoy Nelms 79
- The Electronic Warfare Division - by Various Authors 83
- Organization and Management of the Division - by Don Judd 83
- The Technical Program - by Alan Sewards 83
  - DREO's SEASAT Project - by Jim Salt and Don Judd 85
- The Electronics Division - by Various Authors 89
  - Introduction - by the Editors 89
  - The DREO Navigation Program - by Mike Vinnins 89
  - SARSAT - by Roy McPherson 90
- Radar Division and Its Programs - by Dave DiFillipo 93
  - Airborne Radar - by Malcolm Vant 96
  - Surface Radar - by Bert Bridgewater 97

TABLE OF CONTENTS (CONT'D)

TECHNICAL PROGRAMS NO LONGER AT DREO 99

Programs Once Part of the Chemical Warfare Program - by Jim Norman 101
The Biological Defence Program - to 1969 - by Jim Norman 105
The Energy Conversion Division - to 1986 - by Ernie Criddle 109
The Earth Sciences Division - to 1974 - by Jay Greenblatt 111

ADMINISTRATIVE AND SUPPORT SERVICES 115

Introduction - by Jim Norman and Rita Crow 117
Administration Division - by Jim Norman 119
Program Support Telecommunications Liaison - by Various Authors 121
  Evolution from the Superintendent's Office - by Jim Norman 121
  Evolution from TLO, and the Present Organization 123
   - by LeRoy Nelms, Bill Osborne, and Joan Ross 123
Civilian Personnel Office - by Jim Norman 127
Security, Health, and Safety - by Jim Norman 129

ET CETERA 133

Et Cetera - by Rita Crow and Jim Norman 135

POST SCRIPTS 139

Further Achievements of Some DREO Alumni - by the Editors 141

ANNEX A. ORGANIZATION OF DREO - 1941-1991 - compiled by Jim Norman A-1

ANNEX B. ORGANIZATION OF DRTE - 1945-1967 - compiled by LeRoy Nelms and Jim Norman B-1

HISTORICAL OVERVIEWS

DREO

by

Jim Norman

The Defence Research Establishment Ottawa (DREO) had its roots in Canada's chemical and biological defence programs of the '30s and '40s, in four different Agencies: Department of National Defence (DND) - the Master General of Ordnance; National Research Council (NRC) - a watching brief for DND, a small Chemical Warfare Technical Services Laboratory, the NRC Associate Committee on Container Proofing and Research; Dept. of Agriculture - the Dominion Animal Pathologist; and Queen's University - the Dept. of Microbiology. Each of these Agencies established Technical Laboratories to conduct portions of the defence program of the day and, later, these were merged, ultimately becoming one technical Establishment, the forerunner of DREO.

The earliest activity relating to DREO originated from DND's Master General of Ordnance (through a young staff officer, Major (later, Brigadier) G.P. Morrison) who took note of the Japanese use of chemical warfare against China, and the rise to power of Hitler in Germany (the nation initiating chemical agent use in WWI), and who expressed concerns that Canadian troops would once again be involved in war which involved chemical warfare agents. DND asked the President of National Research Council, Maj-Gen(ret) A.G. McNaughton, to institute a watching brief on chemical warfare, and a young scientist from NRC's Division of Chemistry, Dr. E.A. Flood, was given the responsibility of monitoring the world's technical literature.

In early 1936, DND decided that the deteriorating world situation required an approach more positive than a watching brief and, after discussion with their British opposite numbers, it was agreed that Canada would establish a Respirator Assembly Plant (RAP) similar to the plant in Britain. This facility would be able to supply Canadian Forces (CF) with gas masks and also could augment British capabilities to supply such equipment to British Forces and also the Armed Forces of the other Commonwealth Nations. The RAP, one of the foundation stones of DREO, was established under the Master General of Ordnance, originally at Valcartier, but soon relocated to Ottawa in 1937 to the John Street Annex of NRC's Sussex Drive Laboratory.

As the world situation continued to deteriorate, NRC stepped up the level of its operations, establishing the NRC Associate Committee on Container Proofing and Research, the technical authority for gas mask component manufacture, assembly, and testing. In short order, this became (in fact but not in name) NRC's Associate Committee on Chemical Warfare, and Canada's Steering Committee on chemical defence. In a matching step, Dr. Flood also expanded the range of expertise of his laboratory to cover most aspects of chemical-agent protection, to match the increased demands.

With the outbreak of hostilities in 1939, NRC was charged with the responsibility for marshalling the Nation's scientific and technical resources for war. Its Associate Committee was charged with setting up the various technical projects required for chemical warfare and finding the scientifically trained staff needed.

In 1941, the Associate Committee had grown to be the largest of NRC's Committees and supervised an enormous number of projects, most relating to chemical warfare. In that year, it disbanded and reconstituted itself as the Army's Directorate of Technical Research, very soon renamed as the Directorate of Chemical Warfare and Smoke. This Directorate also took over and operated several Technical Institutes for the Armed Forces. Among others, these included the Respirator Assembly Plant and Dr. Flood's Technical Services Laboratory (and later, the Biological Warfare (BW) Facilities at Queens and at Grosse Ile and, jointly with the British Chemical Warfare Service, the Station at Suffield).

Dr. Flood's Technical Laboratory (another foundation stone of DREO) and the RAP remained co-located in a building next door to the NRC Laboratories at the corner of John and Sussex Streets. In 1941, these two were amalgamated into the Chemical Warfare Laboratories (CWL), the direct forerunner of DREO. Its activities expanded manyfold and its mission became to carry out all needed R&D, and to arrange manufacture, testing, quality control, etc. of all material for chemical warfare. This led to manufacture of gas-proof clothing, gloves, boots, medical supplies, etc.; and even into the design, the construction, and the operation of a plant at Cornwall to manufacture mustard agent. All these manufacturing-type operations involved production operations and CWL was beefed up by addition of a large Pilot Plant, also at the John Street Annex.

At the end of the War, CWL had over 250 projects in chemical defence underway. It had produced, through the RAP, over 8 million gas masks, 40 million canisters, all the charcoal used in Canada's respirators and about one quarter of that used in the US Army's respirators. It had prepared over 400,000 sets of gas-proof clothing and had manufactured over 6000 tons of mustard at its Cornwall plant. The CWL Pilot Plant also produced the entire wartime supply of DDT powder for the Canadian Forces.

At the end of hostilities in 1945, chemical warfare activities declined and the fate of the Chemical Warfare Laboratories became somewhat uncertain. While the military wanted militarily-oriented R&D to continue, NRC did not want to take on this responsibility and decided against continuing military research in peacetime, wishing to return to its original R&D mandate of supporting fundamental science. It most strongly supported the idea that DND should set up a science and technology R&D Agency to do for the Department what NRC did for the country. DND acceded to this advice and established the Defence Research Board (DRB) to take over the scientific-research activities of all three services.

In 1947, the Chemical Warfare Laboratories, still occupying NRC space in the John Street Annex, became a Research Establishment of the newly-formed DRB, under the name "Defence Research Chemical Laboratories" (DRCL).

In the early '50s, there were new forces on DRCL. Firstly, the UN peace action in Korea had some impact on the chemical program. The Canadian Army required large quantities of flame-thrower fuels, and DRCL was charged with the R&D needed to develop a suitable fuel, and then with manufacture of this material. The DRCL pilot plant produced the entire flame-thrower fuel supply used by the Canadian Army in this conflict, working 3 shifts per day, 7 days per week for two years. The Army also established a need for a simple kit to test potability of field water supplies in Korea. DRCL soon designed and manufactured 1500 of these kits for the Forces. These kits remained in service with Canadian Forces until 1987.

The second force on DRCL regarded its location. DRB began the withdrawal of laboratory facilities from downtown and suburban Ottawa to a more remote, more appropriate location, and, in 1951, the consolidation was arranged of all DRB Laboratory activities in the Ottawa area to Shirleys Bay, on land acquired during wartime by DND to expand the Connaught Ranges. Construction began late that year and continued apace through '52 and '53. In February 1953, the new DRCL Buildings at Shirleys Bay were dedicated by the then-Minister of National Defence, the Hon. Brooke Claxton, although relocation of staff was not completed until the late Fall.

In those early years, DRCL's main role was to operate the chemical defence program. DRCL also had been charged with responsibility for two other of the Department's R&D programs: work on flame throwers and fuels, initiators, gelling agents, etc., for flame-thrower chargings; and the program relating to battery and power-sources R&D because both related to expertise in chemistry. (Work on flame-throwers and fuels terminated in 1960, battery work continued.) In 1954, a new responsibility was added, that for the Atomic Warfare program (now known as Nuclear Defence).

In 1955, it was announced that DRCL and its sister establishment, Defence Research Kingston Laboratory (DRKL) were to be amalgamated, and the new organization, DRCL/KL, was to be located in Kingston.

Like DRCL, DRKL had its beginnings in wartime research, also under the Directorate of Chemical Warfare and Smoke. In the time frame of WWII, in late '39-'40, the scientific community had become alarmed at the possibilities for enemy use of biological warfare and began to organize to establish a biological defence program. Two R&D facilities were set up, both under the military's Directorate of Chemical Warfare and Smoke: the War Disease Control Station at Grosse Ile, Québec (later known as Grosse Ile Experimental Station) and "The Kingston Laboratory". At the end of the war, the Grosse Ile Station was turned over to the Department of Agriculture. In 1947, the Kingston Laboratory was taken over by DRB and became the Defence Research Kingston Laboratory.

In 1956, the decision as to location of DRCL/KL was reversed, with the new organization now to be located at Shirleys Bay. This required construction of a "Toxic Wing" (Bldg 5B - completed 1960), an animal colony/animal care facility (Bldg 29 - completed 1962) and a high-containment laboratory Wing (Bldg 5C - completed 1964). In 1962, DRKL's Radiation Chemistry and Radiation Biology programs were transferred to the new DRCL/KL facility at Shirleys Bay. In 1964, the Biological Defence Program also transferred. The establishment's name then was changed to reflect its larger responsibilities and became the Defence Chemical, Biological, and Radiation Laboratories (DCBRL).

The original mission of DRCL was to support the chemical defence of the Armed Forces and this mission continued at DCBRL. The major projects included a system to provide individual protection against chemical warfare agents (and some forms of biological agents) by development of gas masks, canisters, CW protective clothing, CW protective underwear, anti-gas ointment, eyeshields, anti-gas capes, etc. An R&D program to investigate newer and/or better means of detection and identification of CW agents, new decontaminants, new reactions for decontaminants, agent synthesis means, toxicology studies, medical treatment for poisoning victims, and similar work, was put in place. Similar projects, but on a smaller scale, were established for biological-agent protection. Because of work on clothing systems for protection of the soldier against chemical and biological agents, experts in fabrics and fabric impregnation, clothing and clothing design, heat transfer phenomena through clothing systems, etc., were added to the staff and their expertise was soon put to use in programs to increase comfort, fit, wearability, and effectiveness of CW protective gear, including gas masks, particularly in the Arctic. These studies expanded into devising clothing systems for man in the Arctic; and are the forerunners of today's Environmental Protection program.

In 1965, one of the longest-standing activities of the Establishment ceased. The Respirator Assembly Plant was transferred back to the Canadian Army, and its long association with the Laboratory ended when the Army physically relocated it to Coburg, Ontario.

Events with some consequences for DCBRL occurred in 1967. DRB Headquarters were reorganized and many scientific staff duties were transferred to the Establishments. DCBRL was assigned responsibility for the extramural programs in Medical Research, Environmental Protection, Power Sources, Bacteriology, and Nuclear Weapons Effects, and the Defence Industrial Research Office also was transferred to this Establishment. In the same year, the Power Sources Section began an expansion which resulted in creation of a new "Electrical Power Sources Division" with responsibilities for power sources for military field applications. The new Division concentrated heavily on development of new battery systems and new recharging technologies, and on fuel-cell R&D.

Also in 1967, the Establishment's name was changed again, in line with a DRB policy to rename all its technical institutes as "Establishments", to become Defence Chemical Biological and Radiation Establishment (DCBRE). The name was changed yet again in 1968 when DRB decided that its Establishments would be given geographically-related, rather than program-related names and DCBRE became Defence Research Establishment Ottawa (DREO), the name which it has retained to this day.

Major changes came in '68-'69. First, DRB announced major staffing cuts to its NBC Defence Programs of about 50%. Secondly the CW Agent Toxicology program and all of the BW Defence Programs were transferred to DRES. This reduced DREO's programs to Chemical Agent Detection, Decontamination, and Physical Protection, the "Atomic Defence" program and the "Power Sources" program. Both the Chemical and Atomic Programs took staff cuts amounting to approximately 50% over the next two years. As part of this reorganization, the Radiation Biology work was relocated to NRC, to be co-located with the similar NRC program so that a joint DRB/NRC program could be operated. Later, this joint DRB/NRC program took on the major responsibility for investigating the effects of non-ionizing (microwave) radiation on humans. The Establishment also reorganized and a new level of management was added. The Sections were rearranged into "Wings" under "Superintendents", and shortly thereafter these were renamed to "Divisions" under "Directors" (1970).

The second major event in 1969 was the transfer of the other DRB Establishment at Shirleys Bay, DRTE, to the new federal Department of Communications (DOC) to become the Communications Research Centre (CRC). Additionally, the land and all the DRTE elements providing DREO's services were transferred to CRC. DOC continued some DND projects and DREO became the vehicle for control of these projects, establishing a Telecommunications Liaison Office (TLO) to manage the DREO/CRC interface. The group conducting Arctic research for DND had been relocated to DRTE from DRB HQ in the 1967 reorganization and they were transferred (and re-relocated) to DREO to continue work for DND. With time, this group grew to become the Earth Sciences Division, with responsibility for Cold Regions R&D, Arctic Studies, Ice and Snow Research, Off-Road Vehicle Mobility, and Remote Sensing, the last two being with particular reference to movement in the Arctic.

In 1972, TLO expanded to include radar countermeasures, electronic warfare, and non-communication electronics, and later, became a new Division, "Defence Electronics" which, in some cases, continued to operate programs at CRC. In other programs, it added scientific personnel, laboratory facilities, etc., and operated its own programs, either in-house or contracted out to private industry.

In 1974 came the announcement of a new Defence Research Establishment to be located in Winnipeg, to be known as Defence Research Establishment Manitoba (DREM) which would draw its technical programs from those at DREO and the DND Programs at CRC. The Earth Sciences Division, and its programs, as well as about one half of the DND military communications and electronics projects sponsored at CRC, were to be transferred to this new Establishment. Late in 1976, plans for DREM were postponed indefinitely.

The Earth Sciences Division was disbanded in that year, some portions of the work going to DREP and some being apportioned to other DREO Divisions, for example: Remote-Sensing was transferred to Defence Electronics Division, and Vehicle Mobility to Electrical Power Sources Division.

In 1974, the second major event was the demise of DRB* as the operating agency of the DND R&D program and the transfer of most of its responsibilities, Establishments, personnel, etc. to the newly-created Research and Development Branch under a Chief (CRAD), within the Assistant Deputy Minister (Materiel) [ADM(Mat)] Group of DND. This had little effect on DREO's technical programs, except for its reporting to a different senior management in DND.

The Electrical Power Sources Division further expanded in 1977 to become the Energy Conversion Division, adding responsibility for R&D on fuels, engines, etc. In the same year, the NBC Defence Division, having lost its responsibilities for BW Defence, was re-named the Protective Sciences Division. In 1978, the Off-Road Vehicle Mobility Program was transferred to DRES.

Since 1979, the various electronics R&D activities have been gathered together, first into one Division, Defence Electronics, and later divided between two Divisions, the Electronics Division and the Electronic Warfare Division.

In 1985, the Energy Conversion Division was disbanded. Its residual responsibilities have been covered by adding technical expertise to a CRAD HQ Directorate and by operating a small technical laboratory at University of Ottawa.

In 1986, it was decided that all elements of the chemical defence program, except those dealing with development of personal protective equipment such as gas masks and CW protective clothing, were to be transferred to DRES. This consolidation was effected by transfers of Chemical Agent Detection in 1988 and Decontamination in 1989.

The military radar portion of the radar R&D program at CRC was repatriated to DREO in 1988, and a new Radar Division was established from the CRC programs and personnel transferred. One other noteworthy change included the internal transfer of the residual Nuclear Program from Protective Sciences Division to Electronics Division with this Nuclear Program adding an EMP facility to study electromagnetic pulse effects.

DREO currently is organized into four Divisions: Protective Sciences, Electronics, Electronic Warfare, and Radar, to carry out scientific and technical research and development in its assigned technical program areas. It also has two divisions providing support: Administration which looks after finance, supply, maintenance, etc.; and Program Support which offers technical support: the DREO Library, the machine shop, publishing and printing, computer services and similar services. Personnel services are provided by a small Personnel Unit on detachment from the large Personnel Branch at DND HQ.

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* DRB continued as a separate entity of DND for three more years until it was abolished by amendment of the National Defence Act.

Today, DREO is prepared to build on its previous technical successes to advance into the future, and to be scientifically and technically innovative. This will ensure that the capabilities of the Canadian Forces are strengthened, and that the defences of Canada will remain in the forefront of technological advancement.

DRTE - FROM WORLD WAR II TO CRC

by

LeRoy Nelms and Bill Hindson

The present-day Electronics programs: Radar, Electronics, and Electronic Warfare, had their origins in part in Radio-wave-transmission investigations and in part in electronic-equipment development carried out by NRC during World War II. One such program was the development of the Mark III C gun-laying radar. NRC began work on this project in October 1940, and production was achieved in 10 months - about half the time it now takes to just get project documentation through the approval process!

In the early days of the war, the Royal Canadian Navy asked for help in its campaign against submarines, and requested that NRC study ionospheric conditions affecting the transmission of radio waves. An ionospheric sounding station was set up initially in Chelsea, Québec, based on an equipment designed by McLeish of NRC. In 1943 automatic equipment was installed in Churchill and by the Carnegie Institute at Clyde River, Baffin Island. In 1944 a Canadian Radio Wave Propagation committee was formed within DND to coordinate research of the three services in radio wave studies, and also to supervise the (now) 6 ionospheric stations. A small unit known as the Radio Propagation Laboratory (RPL) provided technical supervision, while the stations themselves were operated by the Department of Transport. The RPL was originally housed in Naval Headquarters, and consisted of 3 scientists, Mr. F.T. Davies, Mr. J.C.W. Scott and Mr. J.H. Meek. They were joined later by Mr. J.W. Cox and Dr. R.C. Langille. In 1947 the unit was taken over by the newly-formed DRB and operations moved to a temporary building on the grounds of the Central Experimental Farm of Agriculture Canada in suburban Ottawa, under the supervision of Mr. F.T. Davies. The scientific staff had offices in DRB HQ (then located in "A" Bldg of NDHQ, in downtown Ottawa) from 1947 to 1949, until an additional building was added at the Experimental Farm site.

During 1947 and 1948 "electrical" defence research was carried out largely through grants to Universities. In 1950, a small research staff, 3 scientists, Mr. J.W. Cox, Mr. A. Wickson, and Dr. I. Paghis (plus 4 technicians), housed in accommodation provided by the Signal Corps at Rockcliffe Park, began work on communications equipment problems. This became the Defence Research Electronics Laboratory (DREL). It too was supervised by Mr. F.T. Davies. In 1952, new laboratory quarters built on the Montreal-Road site of NRC were opened.

In 1951, RPL changed its name to the Radio Physics Laboratory (still RPL) and was amalgamated with DREL into a new entity, the Defence Research Telecommunications Establishment, under a Chief Superintendent, Mr. F.T. Davies, while Mr. Scott became Superintendent of RPL, and Mr. Cox Superintendent of the former DREL, now called the Electronics Laboratory (EL). At this time the work at RPL was covered by six sections; Atmospheric Physics, Radio Prediction, VLF, Ionospheric, Microwave propagation, and Theoretical Studies. The Electronics Laboratory had 5 sections; Transistors, Radio Warfare (ECM and ECCM), Components, Navigation, and Radar.

In 1951, the new RPL building (the central wing of the present CRC) at Shirleys Bay was put up and occupied in 1952, becoming the first element of DRTE to move to the new site. Construction was undertaken to house the other elements of DRTE.

In 1957, work was begun on a new wing at Shirleys Bay for the Communications Laboratory, and in 1961 an Electronics Laboratory wing was added. When completed, all of the older disparate elements had been consolidated at Shirleys Bay. With the formation of DRTE, Administration also was centralized and tightened. The new organization had a senior-management level, the Office of the Chief Superintendent which carried the specialized support staff for Technical Illustration, Photography, Library, and Scientific Editor functions. In addition to this "Front Office", there also was an Administration wing which provided Engineering, Construction, and Maintenance Services, a Finance Office, Personnel Services, and Site Services to all of the three laboratories (and to DRTE itself) and many of these services to DRCL as well. [Indeed, DRB HQ often would use these services in preference to making their own arrangements.]

In 1958, the newly formed American Agency, the National Aeronautics and Space Administration (NASA), adopted a joint undertaking with DRTE for the launch of a space-borne sounder to explore the upper regions of the earth's ionosphere. Under this arrangement DRB was to design and construct a satellite while NASA would provide the testing and launch of the spacecraft. This was Canada's Alouette I satellite and its successful launch in 1962 marked the beginning of the very successful Canadian space program, which dominated DRTE activities for many years.

In 1969, when the Department of Communications was formed and DRTE became the Communications Research Centre (CRC), this new Agency continued to provide support to DND in telecommunications research and development through a cooperative agreement, and to operate a portion of DND's technical program, an arrangement that is still in effect.

PERSONAL REMINISCENCES OF EARLY DAYS

by

Harry Sheffer

In 1941, Dr. Otto Maass, Chairman of the Department of Chemistry, McGill University, became Director of Chemical Warfare and Smoke in the Army's Master-General of Ordnance (MGO) Branch at NDHQ. He also assumed for a short time the position of Superintendent of the Chemical Warfare Laboratories, located at the NRC on Sussex Drive. He soon relinquished the latter post to Dr. (Lt.Col.) E.A. Flood, who had his own lab at the NRC and had been interested in respirator ("gas-mask") problems for many years. The NRC gave over one of its buildings on John Street for the production and assembly of respirator components.

Dr. Maass was quite concerned about the possible use of CW agents against Canadian soldiers, as in World War I, and was convinced that we needed protective devices and also a means to retaliate. For the latter, he convinced the Prime Minister that it was necessary to build a mustard gas plant in Canada, but when money was not forthcoming for some time, he personally recruited the necessary funds from a few large Canadian companies (who were later repaid by the government) and obtained an experienced engineer from Shawinigan Chemicals to supervise the construction and equipping of a small plant on the outskirts of Cornwall, Ontario.

In the meantime, in June 1942, as a fresh Ph.D. from the University of Toronto, I was hired by Dr. Flood to work in the "mustard lab" at John Street, along with Dr. Dick Mungen. We, of course, became deeply involved in the operations of the Cornwall plant and built a pilot plant for a new process at John Street (I have the scars to prove it!).

The respirator plant and work on charcoal, filters and protective clothing were the main concerns of others at that site (including a condom testing unit operated by the Inspection Board).

Several of us were shipped off to Officers' training camp at Gordon Head, near Victoria, B.C., returning after three months of pure, very wet, hell, as 2nd Lieutenants. We then continued in much the same jobs, as Army officers (I didn't escape until 1947, having attained the lofty rank of Major).

With the war over, we proceeded to plan a new building at Shirleys Bay. There I subsequently became Superintendent in 1954 and soon took over the operation of DRKL as well.

In a period of consolidation, DRB HQ, in its wisdom, decided to combine DRCL with the much smaller DRKL by constructing a new building at the Kingston site. This idea went so far that I bought a lot and was preparing to build a house in Kingston when the decision was reversed. We added a new wing and new facilities to DRCL and moved the DRKL staff there.

I enjoyed the combined pleasures of having my own laboratory at my disposal and becoming knowledgeable about the wide variety of work proceeding in the establishment. Because of my pleasure in being involved in these activities, I was able to resist several attempts at moving me to more distant locations and other types of interests and managed to remain at Shirleys Bay until 1967, when I finally submitted to removal from my beloved labs and started a new career at DRBHQ.

I have deliberately avoided mentioning names of many of my associates, since it would take pages to describe my admiration for many of their accomplishments, and I would have to include a few less savory incidents as well. Let me conclude by saying that my years at Shirleys Bay were the happiest of my working life, and I owe much to the many who helped to make them so.

SETTING THE STAGE

PROLOGUE - THE PRE-WWII YEARS AND NRC

by

Miles Benson

During WWI the Canadian Army fought as part of the British Army, as colonial troops using British equipment, organization and training methods, facing German chemical-warfare attacks and coping with them using the same procedures and equipment as other British Army Units did. Up to the mid 1930's, the Canadian Army still used the British Army methods and equipment; however, about 1935, the Canadian Army prepared a separate Canadian War Mobilization Table (CWMT)*. Based on the requirements generated in WWI, the British tables listed a number of chemical warfare training and defensive items, including the respirator. The Department of National Defence (DND) in consultation with the British Ministry of Supply continued these items on the CWMT and DND began to single out for special attention, those items with long production lead-times and/or where special production problems could be anticipated.

The problems associated with such items were brought to the attention of NRC. One should not forget that the President of NRC in the late 1930's and early 1940's was retired Canadian Army General 'Andy' McNaughton. It is probable that his influence facilitated the early liaison between NRC and DND. The fact is that he did not have to be given a "hard sell" to convince him of the needs of the Department or the Canadian Armed Services (or of the worthiness of the cause) when asked for help.

At NRC in the early days, there was a real sense of purpose, a dedication, and a teamwork that should be a model. The director of the NRC Chemistry Division was Dr. R. Manske. One of the young chemists, Dr. E.A. Flood, had been a Professor of Physical Chemistry at Brown University before coming to the NRC Chemistry Department. Having worked in NRC from 1938, I was aware that, even though NRC had some elegant equipment, the professional research staff, the programs, and the equipment were limited by budget restraints. Later, when overhead costs were revealed to me I recall being surprised. One example was the cost of the library-facilities operations. Yet without the library, and the various abstracts and abstract services, the scientists could not operate. The funding available for Chemical Warfare activities, however, was considerable and there were spin-offs that were beneficial to NRC.

The respirator was designated as one of those items needing special attention and so plans were initiated to set up a production facility as soon as possible. Although the respirator was actually categorized as defensive equipment, it was reasoned the lack of adequate respirator protection on the battlefield would invite enemy attack.

Another side to this same issue was that it was also reasoned that if the Canadian respirator was inefficient or deficient in operation - a knowledgeable enemy would soon know this and the weakness would invite attack. It was clear that each person on the battlefield needed a respirator with an adequate supply of spares and back-up. In addition, the respirator facility must be able to respond quickly to any new enemy threat. This meant that in addition to assembly and quality control facilities, a team of knowledgeable people must be available to analyze and counter the threat.

The Respirator Assembly Plant (RAP) was originally set up at Valcartier, Québec, using British specifications and drawings for the 52 components of this mask. It soon was clear that the drawings and specifications would need radical modification before Canadian production of the components was possible. The very complex nature of the special activated charcoal for canisters made it necessary to get qualified and knowledgeable technical specialists, with good laboratory facilities, to verify the proper function of the respirator.

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* It is worth noting that an IBM main-frame computer was brought into use to assist with this task. This early use of a computer permitted the quick data manipulation and revisions, when needed. This system was based on key-punch input and card or printed output.

It was recognized that a life depended on the proper function of the respirator and on this basis, the quality control of the respirator production was taken very seriously. The basis of this technology and of the needed quality-control was not available in Canada and had to be imported.

It took considerable time to activate the RAP because of the time needed to:-

- set up the production line
- revise component drawings and specifications
- find the level of supply needed
- get financial approvals
- find qualified component suppliers
- provide lead time for component supply
- training time for assemblers.

At the same time, Dr. Flood of NRC was asked to import the technology and set up a laboratory to further develop the respirator, to develop Canadian charcoal facilities, to provide sound quality control, and to train people to the high skill levels needed.

NRC actions to set up a technical facility at Ottawa prompted a move of the RAP from Valcartier to the NRC John Street Annex in 1937, and was designed to bring the technical and manufacturing people together. Dr. Flood also was given the task of reviewing and revising where necessary the respirator component designs.

During 1937 and 1938, Dr. Flood had been gathering information about charcoal and respirator manufacture and had been doing liaison with British scientists in the British Ministry of Supply concerned with respirator manufacture. During the summer of 1939 he managed to get space and facilities to set up a charcoal-testing laboratory in the main Sussex Street building. NRC hired Taylor Coombs, and I was transferred from the Plant Biology Division, to work for Dr. Flood. The initial task was to design, acquire parts for, and build the first-generation test apparatus for charcoal testing.

Also during 1939, a number of the training "War Gases Smelling Kits" were made up, assembled, packaged and shipped to the army in compliance with an urgent army demand. In addition, a number of chloroacetophenone capsules were filled and shipped to the army for training purposes.

These activities kept us quite busy until the outbreak of war.

THE WAR YEARS

by

Miles Benson

FROM NRC TO CWL

As NRC shifted to a war footing, Dr. Flood's laboratory was asked to continue its work on respirator and canister technology, and also take on more and more chemical-warfare related tasks, and became known as the Chemical Warfare Laboratory.

The work on the setting up of the charcoal testing lab was continued into 1940. A large quantity of activated charcoal had been received from a number of different sources. Methods of sampling, methods for maintaining material identification and traceability were devised and systematized.

The charcoal specifications, the charcoal technology and the canister design were essentially British. Dr. Flood had already made contact with the British Ministry of Supply and scientific, technical and engineering documents were being made available to NRC.

In 1940 the production of about 1000 pounds of dyestuff B1 was undertaken in the NRC pilot plant. B1 was the active ingredient used in detector powders, paints and papers used for the detection of the chemical agent 'Mustard Gas', and was at the time classified 'confidential'. Dr. Flood subcontracted the job back to others at NRC. Dr. Manske, Dr. Marion and Mr. A. Ledingham handled the planning and technical aspects and Dr. Flood loaned Coombs and Benson to implement the production. After the batch production was complete, a specification was written to enable the product to be sent to industry for future production supplies. The labour force synthesizing the B1 dye stripped and put on coveralls to work, and showered after each shift. However, each person did wear his own shoes and one day, one individual going home in the rain noted that every step left a size 10-1/2 red-dye footprint mark on the pavement (and on the floor of the street-car). No one appeared to notice, but the next day all workmen started to wear plastic covers over their shoes so that the material was not tracked out of the plant.

At this time, Dr. Flood was asked by DND to appraise the materials and items needed for chemical defence in addition to the Respirator. Coordinated with DND Ordnance Corps supply officers, a study was made of the supply status for each item or material: Were the material specifications adequate for Canadian manufacture? Were drawings available, where needed? Were there some items that could not be supplied quickly (or not be supplied at all) by Canadian industry?

In 1940 when Britain was being stretched to the limit by the German attacks, they needed all the help Canada could give in the supply of materials and equipment. The program for supply of chemical-defence equipment was thrown into high gear during early 1940. During the summer, Dr. Flood had a series of university students for a series of short trial periods. Each was evaluated with the idea of developing a cadre of good technical people that could be called if and when needed in the future, under wartime pressures. CWL added many of these summer students to the staff, they were from the Graduate Schools of McGill, and other Canadian Universities, and arranged largely by Dr. Otto Maass (see later). The British Ministry of Supply posted Mr. J. Haddow to CWL to assist with the interface of the NRC labs with those in Britain at this critical time. Mr. Haddow had worked at Porton, Wiltshire, and knew the British equipment well. His knowledge of where and how to find documentation was particularly useful at this stage. All tasks were given a priority rating, and many tasks were turned around with unbelievable speed. There was a great team spirit and no need to explain the need to be fast and efficient.

About the same time, another person from Britain joined NRC but worked almost exclusively for CWL. George Ensell was employed by the Mines Branch and seconded to NRC. He was a fully trained glass blower who had been apprenticed for five years and had an additional twenty years experience. Dr. Flood knew he would need to have vacuum racks and many instruments and devices made from glass and this was his answer. Mr. Ensell built equipment that CWL needed but was impossible to buy. He also trained the staff to blow glass and many CWL technicians became very proficient, and their skillful efforts spread the glass-blowing benefits over a broader base. Mr. Ensell was awarded an MBE at the end of the war for his outstanding service to CWL.

Liquid air and liquid nitrogen was another facility needed. At that time there was no reliable supply in the Ottawa area. The NRC "Linde" liquid-air machine had broken down in use and been unserviceable for some years. No one had the funds or inclination to repair it. This was my next task and I found that, in addition to repair, some redesign was needed to be sure the machine would continue to operate reliably for some reasonable amount of time. The refurbishing was completed and the Linde liquid-air machine again operated to its original specifications and continued to do so for the duration of WW II.

During 1940, a complete library of chemical warfare documents was sent to DREO by the British Ministry of Supply. These were the duplicate copies of all the reports stored by the British for an emergency situation. They now considered they were in an emergency situation because of the German bombing raids and the threat of a German invasion and felt it was time to move these documents to a safer place. Some documents were sent to Canada at once, but the bulk of this library arrived the following year, and I took on the organization of the transfer of the UK document library. I hired a librarian and a helper, and a photographer, set up a dark room, arranged for library space, had an outer area with locked files and had a large vault built for more sensitive documents. CWL acquired a "recordak" camera for document microfilming, to provide a back-up copy of each document. All photocopiers were slow and inefficient in the year 1940, and this was a full-time job for several years.

During this period, the chemical-warfare work introduced new hazards that were not normal to the work place, also, the pace of the work was not consistent with that of normal peacetime research. In those years, laboratory workers were not as conscious of worker safety as today. Some accidents were predictable. One of our first significant accidents involved a chloropicrin spill in the NRC main building when a metering device failed. One technician was exposed and when taken for treatment, we then found out that there was no medical doctor in Ottawa who knew anything about chemical agents. In addition, there was no equipment available for doing the blood work needed in such a case and no technicians trained to do the blood work and even if there had been there was finally no medical specialist who would know how to interpret the results. The technician survived. New safety routines were established in the labs and, when the need was explained to them, the Ottawa Medical Association undertook to cooperate with NRC and asked a Dr. Fisher to set up a blood lab. Dr. Fisher then was given access to information concerning the diagnosis and treatment of CW victims. Routine blood samples were taken for those working with hazardous chemicals by Dr. Fisher and when CWL acquired a full-time medical officer, Dr. Fisher continued as a consultant. The blood lab and Dr. Fisher became a useful resource not only to CWL but the whole City of Ottawa. Some time later when the information concerning the 'nerve' agents became available, Dr. Fisher was able to diagnose and treat patients with "Myasthenia Gravis". In the Ottawa area a number of these patients for years had been misdiagnosed and had not been receiving proper medical treatment.

During 1941, Dr. Flood's staff increased from himself and two assistants to a staff of about ten. I was appointed as administrative assistant to Dr. Flood. The new staff included several candidates with PhD degrees and these included Dr. Don Dewar, Dr. Jack Dacey, Dr. Tom King, Dr. Stan Naldrett and Dr. Ross Harvey. There was a first attempt to delegate some of Dr. Flood's main responsibilities to the new staff and during the "settling down" period these were passed out (on a trial basis) to find which staff members were comfortable with what areas of responsibility.

Lab space in NRC Sussex increased to five labs, space was being renovated at John Street to allow a further expansion of the chemical warfare programs which were now expanding quickly. RAP quality-control testing was set up at John Street, and included test stands on which production-line samples of the current production could be proof-tested against the actual war gases: phosgene, chloropicrin, hydrogen cyanide, etc. Other tests included particulate tests for the filter media, and leak tests to verify the integrity of the canister.

Ross Harvey introduced selected members of the CWL staff to a basic electronics course and an electronic-instrument shop was set up. A variety of electronic instruments and equipment such as timers, ultraviolet photometers, spectrographs, etc. needed by the scientists at CWL was built and put into use. I supervised this shop. In addition to instruments built for CWL, some instruments were built for others, for example: diode scaling counters for AECL Chalk River, and VHF sky-bounce transceivers for NRC.

Samples of the prototype CW-protective eyeshields and anti-gas ointment were obtained from commercial sources and evaluated. Specifications were written to permit their supply from commercial sources.

During 1941 some, but not all, of the CWL laboratory operations were relocated from NRC Sussex St. to John St. The charcoal-testing facility was moved and a complete new respirator-proofing lab was built. Several months were required to build the equipment, fume hoods, verify the correct working of all test equipment etc. Also, because of the volume of testing required, a staff of test operators were needed and these were selected from the staff of the respirator assembly plant and trained. This was intended to give support to the production facility by daily proof-testing (random production samples of the RAP). This included proof-testing of the canisters on actual war gases. The filter media of the canisters were tested using the methylene blue or dioctyl phthalate test apparatus. Additional tests were devised and tried on an experimental basis for 'hydrogen cyanide', 'arsine' and 'cyanogen chloride'. The chemical cyanogen chloride was synthesized. Drs Malloch, Penny, and King were involved in providing assistance and back-up technology when required.

CIVILIAN TO MILITARY - TRANSFER OF CWL TO DND

The NRC Associate Committee on Chemical Warfare and Smoke, chaired by Dr. Otto Maass of McGill University, had become the guiding entity for the wartime Chemical-Warfare Program. Dr. Maass himself had had a distinguished career. He had been attending university in Germany when World War I (WW I) broke out. His friends 'spirited' him out of Germany so he could rejoin his family in England. He remained in England during the war and reportedly was involved in war work for the British government. Some years later he immigrated to Canada to become McGill University Professor of Physical Chemistry, Chairman of the Chemistry Department, and Chairman of the Pulp and Paper Institute, and during and after WW II, became Scientific Advisor to the Canadian Army's Chief of the General Staff.

Operating a full-scale wartime military program from NRC, however, became too difficult, and the solution was to transform the whole from civilian to military status. The Army created the Directorate of Chemical Warfare and Smoke with Dr. Maass as its Director, carrying on all the activities set up by the NRC Associate Committee. He refused a military commission, continuing on as the civilian director.

In a matching step, CWL was also converted from civilian to military status. Dr. Maass was its interim Superintendent but, shortly, he relinquished this to Dr. Flood, now Lt Col. Flood. In the summer of 1942, the staff of CWL also was converted from civilian to military status. This avoided conflict between the need for lab staffing and other military needs, and allowed the military to assign its technically-qualified personnel to appropriate positions. The staff (with a few exceptions such as clerks, typists, etc.) were all inducted into the Army. Most had no military training, and, when joined to the Armed Services, each person had to undergo basic military training, either for officers or for NCOs.

I was "commissioned" on 15 July 1942. Jack Arnell, Taylor Coombs, Harry Sheffer and I all went to Gordon Head, B.C., for the officer training course (referred to by Dr. Sheffer) in the late fall of 1942. We returned as 2nd Lieutenants. Others, including Tom King, Stan Naldrett, Dick Mungen, and Jack Dacey, took an earlier officers training course at Brockville. I got a double dose of officers training having already taken a similar officer training course at Barriefield, Ontario for the Royal Canadian Engineers.

The technical work expanded manyfold. During the fall of 1942, a study of laboratory production of fluorine was started, which resulted in the first apparatus being built to make small quantities before the year end. There were many problems, particularly in the fabrication of an apparatus that would contain the fluorine. Dr. Dacey was involved in providing scientific back-up for the project. This work stretched into the next year. This work was exploratory, exasperating, slow, and with many very tough problems.

Also during 1942, mobile laboratories for Army Field Operations were designed and built. These were intended for collection on the battlefield of samples of materials contaminated by CW and/or BW agents, and those selected to operate these mobile facilities were indoctrinated into how to do field sampling and analysis using the mobile equipment. Working with the medical staff of McGill University, specialists were gathered into a team to evaluate the threat and devise safety measures for those who would operate the mobile labs. We were never told the exact nature of the injections given to immunize the lab operators. Plague, beri-beri, dengue, and others were included in this injection which used horse serum as a medium. In some cases the injection effects were immediate and dramatic -- the subject was immediately rendered unconscious and then had a three-day hangover while recovering. My immune system responded by causing me to become allergic to many things. Skin tests by an allergist vs 52 substances indicated a sensitivity to all of them, with a triple reaction to more than twenty. I could detect an upwind horse at a distance of more than a thousand yards from my allergic reaction.

Full-scale production of military respirators was carried out for about a two-year period. Managing the proof lab and training the staff proved to be an active assignment. During this period, a requirement for two million civilian masks as a backup to the British production capability, then under serious threat from bombing, was identified. The decision was made to set up a separate civilian respirator plant. The staff selected were sent to CWL for indoctrination and training. As I recall about fifteen trainees were involved.

The respirator face-mask 3D shape and sizing reportedly were based on a statistical study made by a Canadian anthropologist. The respirator face-mask moulds and the production of the rubber portion was done by industry for the early production. The CWL pilot plant was seeking a way to make changes and to experiment with face-mask moulds to be able to use a different size and shape of inlet valve, to revise the air-flow pattern inside the mask etc. The moulds for making the mask called for the use of a Keller 3D Shaper (the common name used was Keller Duplicator). These machines were in short supply and the chemical warfare need did not warrant a priority high enough to obtain one for CWL use. Instead, development lab personnel were given an internal training course on clay modelling and sculpturing (using classical casting methods similar to the lost wax method) to fill the need for 3D studies. This was an off-shoot from the teaching I was already doing at a studio in Ottawa for artistic purposes. I believe Mr. Wib Cowie also had some limited success with development of a 3D duplicator using hydraulic drives instead of the mechanical drives used by the Keller Duplicator.

Preparation of elemental fluorine became a major CWL project to support work on toxic sulphur fluorides. I was transferred back to the main NRC Labs in 1943 to set up a facility for producing laboratory quantities of fluorine. This was to be used for the synthesis of other chemicals. After trying various materials for fabricating a fluorine generator, I found the only materials to stand up to the conditions (molten calcium fluoride at about 250°F and gaseous fluorine at the same temperature) was copper. The president of Anaconda Copper donated a 40-foot length of seamless tubing for our equipment, sufficient to manufacture all our equipment for fluorine production. Before production could proceed and the fluorine could be handled, Dr. Dacey had to carry out a research project to find a method to verify the purity of the fluorine. A series of equipments also had to be devised, including the development of a fluorine flowmeter, the development of electronic control equipment to handle control of voltage stepping and overvoltage, and, finally, new methods and means of liquefying and handling the elemental fluorine were required. In the process devised, the fluorine was liquified using super-cooled liquid nitrogen, supercooled by being put under reduced pressure.

Fluorine production then was run full-scale, and about 20 pounds were produced and used for experiments involving iodine, bromine, cobalt, and silver fluorides. About 20 pounds of silver fluoride were produced. Chlorine trifluoride was produced as an specialized incendiary device and was found to be very aggressive. About 200 pounds of fluorine were produced to the year end. I then became involved in the synthesis of other fluorine chemicals.

Laboratory quantities of disulphur decafluoride were produced. (The byproduct, sulfur hexafluoride, was much sought at the time by the USA AEC for separation of uranium isotopes). The physical and chemical properties and toxicity of S_2F_{10} were determined and it was decided to make a quantity for field tests. Jimmy

Dale and Don McLeod built a pilot plant in the John Street Annex in 1945 and made larger quantities of disulphur decafluoride, in space CWL had not occupied before. This space was adjacent to, and just north of, the building on John Street occupied by the National Film Board of Canada.

A major problem encountered with S_2F_{10} production was with the low-temperature distillation and with separation of other sulphur fluorine compounds.

The fluorine project was put on a 3-month hold at the urgent demand of the Canadian Army while a charcoal "Whetlerizing" plant was set up. This was for special impregnation of the charcoal in the mask canisters to be provided to Allied Troops in the then-upcoming Sicily invasion.

Many other shorter-term and ad hoc projects also were tackled. By the end of WW II, CWL had over 250 projects and tasks on the go.

Later tasks after the war included:

- Research into Geiger tubes, resulting in a prototype and specifications. New commercial sources made the further continuation of this work unnecessary, however, the insight gained during this work was of value later when it became necessary to have Geiger and electrometer tubes developed for the Canadian Armed Services.
- Cold weather field trials, in 1946, of anti-gas equipment under arctic conditions, at Churchill, Man., by Major Ross Harvey. Informal outdoor tests were carried out in Ottawa which revealed some cold weather problems with the chemical equipment, particularly the respirator. Some other tests were performed in the NRC cold chambers prior to field trials at Churchill, Man.
- Tests of a rubber protective suit for protection against ammonia was carried out for the Ontario Fire Marshals' Office by Ross Harvey and Glen Gay. The tests showed the suits to be almost completely ineffective.
- Literature survey "Clinical Uses of British Anti Lewisite (BAL) by Ross Harvey and Glen Gay.
- Naval trials in 1946, using the Haida to test the use of smoke floats for screening a landing operation, by G. Wilson and Miles Benson.
- A study of methods to extinguish cordite fires in tanks and armoured vehicles in ambient temperatures from minus 20 to plus 120 degrees Fahrenheit by Miles Benson, René Boyle and Colin Hyde. Successful extinguishing mixtures were found.
- In 1949, DRCL conducted a study of the radiation ground pattern around the main stacks at AECL. Following this, the stack internal contamination, and particle-size analysis of the effluent was performed by Miles Benson. The source of ground contamination was found. It was recommended that the effluent be filtered, and the practice of dissolving spent fuel rods (X Bars) in acid be discontinued. Subsequently, UK nuclear scientists read the report; they too installed filters on the stack of their newest reactor at Harwell.

One of my last jobs was to determine the space requirements of the new laboratory building for DRCL. This included a survey of special apparatus needed, and the needs of the individual scientists. This led to a conceptual plan for the laboratory which then could be firmed up by the architect. The end result of all this was the construction of Bldg 5 (now 5A) at Shirleys Bay.

POSTWAR - DRB, DRCL, AND THE MOVE TO SHIRLEYS BAY

by

Jim Norman

By late 1947, the National Defence Act had been amended to create the Defence Research Board. Its mission was to conduct the necessary scientific and technical R&D for all three Services of the Canadian Armed Forces. To this end, the newly-created Board took over the Service's R&D Establishments, and also their staffs. Programs were reviewed, new programs were formulated, old programs were modified (or, in some cases, terminated), and, as a result of these procedures, new programs for the Establishments satisfactory to the military and to the new Board were arrived at.

CWL, along with its staff, was transferred from the Army's Master-General of Ordnance to the new Board and became the Defence Research Chemical Laboratories, DRCL. Its mandate was largely unchanged: to operate DND's R&D program in chemical warfare defence (and, although never stated officially, to keep alive in Canada the technology of manufacturing gas masks and canisters); and some new responsibilities relating to chemistry problems of a more general nature, for example, a batteries R&D program and a flamethrower fuels technology program. In addition, its expertise was tapped by the International Joint Commission to provide the Canadian share of studies of atmospheric pollution in the Windsor-Detroit region. DRCL provided and staffed a laboratory under Dr. M. Katz in Windsor to apply the techniques of air sampling developed by the Chemical Defence program, to remove solid aerosol particles and chemical vapours from air, and to analyze and identify the materials collected. This program eventually was transferred to another government department, and DRB's and DRCL's involvement in this program was terminated in 1952.

DRCL's R&D program, while running smoothly in 1947, was shaken up by the decision to move the laboratories from their John and Sussex location in downtown Ottawa to the remoteness of the new site at Shirleys Bay, one that did not even have access by public transportation, however the concerns of staff were met and practical details were worked out by representatives of the employees and Senior DRCL and DRB management.

In 1946, Dr. Flood who had guided CWL and the RAP during most of its existence decided to leave and to return to NRC, and Dr. J.R. (Jack) Dacey replaced him as Superintendent. With the transfer in 1947, he became the first Superintendent of DRCL. He had two priorities: to get the scientific and technical programs onto firm footings and to ensure that they were properly staffed, funded, etc.; and to plan the move to Shirleys Bay. He left for a new appointment at RMC before the plan for the move was well advanced and it fell to Drs. J.C. Arnell and Harry Sheffer to complete the planning and (eventually) oversee the move.

Construction at the new site began in early 1951 and by late '52, some buildings had advanced far enough that they could be occupied. As these facilities were finished, the various elements of DRCL packed up and moved, and then set themselves up again and restarted their programs. The first to move was the Pilot Plant; by the Fall of 1953, all the other elements had relocated, DRCL was ensconced at Shirleys Bay and the old John and Sussex quarters had been abandoned. A further year was required before the transplanted technical programs had overcome the multitudes of small oversights and glitches and were running smoothly again.

The programs of the day, of course, were largely concerned with chemical warfare problems and the new problems of batteries and flamethrower fuels, and it was not until 1955 that elements of Nuclear and Biological Defence Programs were added. These later increased, to assume an increasingly more important role at the Establishment, and the story of the NBC Defence Programs at Shirleys Bay is told below.

THE NUCLEAR, BIOLOGICAL AND CHEMICAL DEFENCE PROGRAMS

OVERVIEW

by

Jim Norman

BACKGROUND

The NBC Defence programs have been the longest standing at DREO or its forerunners -- all predate DREO (and DRB) and all have their origins in the frantic application of science and technology to wartime activities to win WWII. All were portions of an intense, intimate, cooperative, coordinated wartime scientific effort mounted by Canada and our major wartime allies, the United Kingdom (and the Commonwealth) and the USA. For most projects, the activities were so intertwined that it is hard to tell where one Nation's efforts left off and where another's began. One noteworthy point about these wartime activities was the size and scope of the Canadian programs. They were far larger than might be expected based on the population and financial resources of the nation. Indeed, they were nearly the equal of the corresponding British and American efforts, and reflected the Canadian military's unease that, somehow, WWII might become a replay of WWI, and Canadian troops once again might have to operate in a chemically-contaminated environment.

This international cooperation in NBC Defence engendered during wartime continues to this day, through the TTCP organization of Canada, the UK, the USA, Australia, and New Zealand for collaborative scientific R&D; and through the similar military cooperative agreements; for example, the ABCA (Armies), ASCC (Air Forces), and ABC-IEP (Navies) Agreements for development, production, and standardization actions. Our military alliances have grown since WWII and other cooperative agreements also are in place; for example; NATO, the Franco-Canadian Accord, the Canada-Netherlands Bilateral Agreement on CB Defence, and the US/UK/CDA MOU on CB Defence, to name but a few. Canada's R&D programs in NBC Defence are heavily involved in collaborative work through these agreements, as well as in the extensive collaborative programs through the much older TTCP agreement. It should be noted, however, that our closest relationships and the fullest integration of our NBC Defence programs are with our oldest allies and partners, the UK and the USA.

As a corollary to this, not all of our ventures in these areas can be described fully. Some still carry security classifications and restrictive legends imposed by our allies which we cannot violate.

ORGANIZATION AND ADMINISTRATION

The original role of CWL and RAP was to conduct the wartime chemical defence program, and all of its resources were devoted to that Program. A very loose management was in existence with Dr. Flood supervising the science and technology activities of CWL. He also had an advisory role for the RAP. In general, the individuals conducting the work reported directly to Dr. Flood. For the biological program, similar loose arrangements prevailed for the programs at the Kingston Laboratories and the Grosse Ile Experimental Station (GIES), with individuals reporting directly to the officers-in-charge for these two establishments.

Tighter organizations came into effect with the wind-down of wartime programs and the advent of DRB. Individuals conducting similar work were organized into "Groups". By the late-'40s, early '50s there were: Detection, Organic Chemistry, Fluorine Chemistry, Electrochemistry, Flamethrower Fuels, and Protective

Equipment Groups and also the Pilot Plant and Respirator Assembly Plant. In 1953-54, the first responsibilities for nuclear defence appeared with the addition of Radiation Physics and Radiation Chemistry Groups. In the following year much more formal organizations for DRCL and DRKL had emerged, each under a Chief Superintendent, with an Administrative Officer, Library Services, and with the former Groups being merged into common-interest Sections. Radiation Physics and Radiation Chemistry Groups became the Atomic Warfare Section; Detection, Organic Chemistry, and Fluorine Chemistry merged into the Chemical Warfare Section; Protective Equipment, the Pilot Plant, the Respirator Assembly Plant (RAP), and the Rubber and Plastics Group were merged into a Protective Equipment Section with a Chemistry Group added to look after the testing and R&D needs of the RAP and of prototype equipment developed at DREO, and Electrochemistry and Flamethrower Groups merged into a General Chemistry Section. In 1961, the forerunner of today's organization at DREO emerged. Sections were grouped into "Wings" under a "Wing Superintendent" (and contact with "the boss" became hazier and more difficult for the staff). The Wings were: the "A" (Atomic) Wing with responsibility for the nuclear program, "B&C" (Biological and Chemical) Wing with responsibilities for the Biological and Chemical Defence programs and also the General Chemistry and Electrochemistry Programs, and "D" (Development) Wing responsible for development and engineering activities to support the other programs of DREO, and to run a small program on development of protective clothing and equipment for the Arctic. After about five years, the Wings were renamed, as Divisions and at the same time the General Chemistry and Electrochemistry Sections were removed from the B&C Wing. The general chemistry program was cancelled (its assets and people were absorbed by the Chemical Warfare Section) and Electrochemistry became, first, the Power Sources Section, and then, the Electrical Power Sources Division.

In 1969, the former A, B&C, and D Divisions were merged into the Defence NBC Division. The Directors of these former divisions became Deputy Directors in this new organizations. These Deputy-Director positions lasted until the incumbents either left for other positions or retired. In this year, the Division also lost the responsibility for the biological program. It was transferred to DRES and amalgamated with the similar program there, however the name of the division lasted until 1976 when the name was changed to the Protective Sciences Division. During the 10-year period of 1966 to 1976, the original 11 Sections of the A, B&C, and D Wings shrank through close out, amalgamation, etc., to the 6 Sections of the Protective Sciences Division. The number of Sections then remained constant until 1982.

The multitude of changes to the NBC Defence organization of DREO has made it difficult to write the history of the NBC programs in terms of Groups, Sections, Wings, Divisions, etc. For the time period to approximately 1982, we have opted for short histories of each technical program, written, in general, by individuals deeply involved in these programs. To continue the story after 1982, Charlie Clifford then picks it up and has written the story of his Division and its technical programs up to the present.

The present organization of the Protective Sciences Division front office includes Brian Harrison as the Director, Jim Norman as the Senior Scientist Chemical Defence, and Trudy Scott (Vaughan) and Marylou Bowden as the secretaries.

The present Division has evolved from the original "Wings" organization of DRCL. "A" Wing was under Jim Flynn with Bep Laroque, and much later, Anne Edsell, as the secretaries. "B&C" Wing was under Harry Sheffer, then Murchie McPhail, with Dorothy Belaire as secretary. "D" Wing was headed by Wib Cowie. Secretaries included Pat Gregoire, Lillian Cavanagh, Gloria Penny (Beck) and Anne Edsell. The NBC Defence Division under Bob Heggie was formed by amalgamating these Wings and adding a Scientific and Administrative Assistant, Harry Nash. Secretaries were Dorothy Belaire, Gloria Penny, Bep Laroque, and Marcy Dubois (at the NRC location). The Division then became the Protective Sciences Division under Parr Tate. Bob Simpson was the Division's Administrative Clerk and the secretaries included Dorothy Belaire, Gail Gosselin, Mary Anne O'Keefe and Sue Billo (at NRC). Charlie Clifford succeeded Parr Tate, and Gid Silverthorn became the Administrative Assistant. Secretaries were Dorothy Belaire, Mary Anne O'Keefe, Trudy Vaughan, and Marylou Bowden.

NUCLEAR DEFENCE RESEARCH AT DREO - 1953 to 1982

by

Parr Tate

BACKGROUND

In order to understand the reasons for setting up a nuclear-defence research program at DRCL in 1953 it is necessary to consider the international situation at that time. The cold war was in full swing. The USSR had exploded a nuclear weapon in September 1949 and had carried out a number of further tests since then. A Soviet thermonuclear weapon was exploded in August 1953, to the consternation of the allies in the West. Soviet policy was, and had been, very aggressive in many parts of the world. A Soviet-sponsored coup in Czechoslovakia had resulted in a communist government in March 1948. The Berlin blockade and airlift had started in June 1948 and continued until September 1949. The Korean War had started in 1950 and a provisional armistice agreement was only reached in July 1953. There was no nuclear stalemate to give any sort of stability to the international situation. Hostilities were not at all a remote possibility and it seemed that any war which started would be likely to escalate quickly to the use of nuclear weapons.

Canada had cooperated closely with Britain and the United States on the development of nuclear energy during World War II which had only ended some eight years previously. In fact, the major part of the British effort during the war had been carried out in Canada. One event of major consequence for both Canada and Britain, however, was that, in 1946 the US Congress had passed the Atomic Energy Control Act (also known as the McMahon Act) which severely restricted the passage of information on atomic energy, as nuclear energy was generally known at the time, to other countries. Britain and Canada were essentially cut off from the United States as far as information on nuclear weapons was concerned. The restrictive nature of the McMahon Act was prompted largely by the revelation of extensive spying by foreign scientists (many of them employed in Britain and Canada) and the extensive leaking of atomic information as revealed by the Gouzenko affair in 1945.

Britain decided (a decision made by the Labour government of Clement Attlee) to continue with the development of nuclear weapons which had been begun in 1940. Development had been carried out at the Atomic Weapons Research Establishment (AWRE) at Aldermaston since 1947. This, of course, predated the US nuclear program.

Canada had never had a program to develop an independent nuclear-weapons capability, but had participated with the US and UK during World War II in research and testing of chemical and biological defences including development of retaliatory capabilities. Some in the Canadian defence scientific community regarded the development and acquisition of nuclear weapons by the Canadian Armed Forces as a logical progression of that work although even then it was recognized that obtaining the necessary political approval would be difficult. There was, however, an undoubted need for knowledge of nuclear-weapons effects which might best be obtained by some hands-on experience.

Owing to its wartime manpower needs, Britain had experienced a reduced production of trained scientists and was seriously short of scientists to staff its nuclear weapons program. The Chairman of the DRB, Dr. O.M. Solandt, offered to lend Canadian scientists to AWRE and this offer was accepted. As a result, four DRB scientists worked in the early UK program and participated in the first UK nuclear-weapons trial, Operation Hurricane, at Monte Bello Island off the northwest coast of Australia in October 1952. In 1953, three other DRB scientists were seconded to AWRE as replacements.

The explosion of a thermonuclear device by the USSR in August 1953 surprised and shocked senior staff at defence headquarters in Canada by demonstrating the rapid increase in Soviet capability. DRB decided to allocate a considerable amount of effort to nuclear-defence research and suggested as a goal 50% of the efforts at Suffield Experimental Station (now DRES) and DRCL be diverted in that direction.

Dr. J.A. (Alex) Carruthers had been one of the Canadian scientists seconded to AWRE and had been responsible for measuring the thermal effects of the nuclear weapon at Operation Hurricane. He returned to Canada in 1953 and was charged with setting up a Radiation Physics Group at DRCL.

SCIENTIFIC PROGRAM

The scientific program at DRCL was determined by the Superintendent and the senior scientists themselves, with advice from DRB headquarters staff and committees of the armed services. Much attention was paid to the need to coordinate work with programs in other allied countries. This was done through the Tripartite Conference on Radiological Defence and later through the Tripartite Technical Cooperation Program (TTCP). The term "tripartite" referred to the three countries, United States, United Kingdom, and Canada, who had agreed to coordinate their research programs. Later on, Australia became a participant as well in The Technical Cooperation Program.

Following much international discussion, it was decided that DRCL should be active in five areas: thermal effects of nuclear weapons, radiac instrumentation, physics of ionizing radiation, and the chemical as well as biological effects of ionizing radiation.

Thermal effects of nuclear weapons had important military implications and there was a need to advise the Canadian military in that area. Some expertise was available. A Canadian scientist had acquired some practical experience during actual nuclear trials, and there was the prospect of further participation in British trials.

The term "radiac" of radiac instrumentation is based on an acronym standing for "Radiation Detection Indication and Computation" and is an agreed term in the military context referring to radiation-measuring equipment. The Canadian Armed Services of that time had been equipping with radiac instruments but had encountered technical difficulties. They were in great need of both scientific input and engineering support.

The Physics of Ionizing Radiation Program had application in the shielding of personnel from radiation and in the study of the deposit of radiation dose in the different organs of the human body while the Chemical Effects of Ionizing Radiation Program had a military significance in the possible development of chemical devices to measure radiation dose and in the understanding of mechanisms by which radiation produced deleterious biological effects.

The Program on Biological Effects of Ionizing Radiation initially was located at the Defence Research Kingston Laboratory with other biological programs but came to DRCL when the laboratories were merged. Its military significance lay in improved knowledge of the effects of radiation on troops and the search for medical means of protecting them or of improving recovery from these effects after exposure. An important objective of this program was to maintain an ability to advise military and civil-defence medical personnel on ionizing-radiation effects.

At a later stage when it became clear that there was no further need of thermal measurements at atomic trials (British land-based testing ceased after 1957), research effort was diverted to a study of some basic properties of ions. The work supported design of ion chambers which were extensively used for radiation detection, and ion physics became part of the program.

THERMAL EFFECTS

In August 1954, Dr. O.M. Solandt, Chairman, DRB made an offer of Canadian scientists to assist AWRE in carrying out the atomic-weapon trials planned for 1956 and 1957 in Australia. The offer again was accepted and it was agreed that teams from SES would make shock-wave measurements using the smoke-rocket technique, and attempt to measure flux and spectrum of neutrons from the weapons via their associated beta rays. A team from DRCL, led by Alex Carruthers, would be responsible for thermal measurements (he had previous experience in this field). Thermal radiations from nuclear weapons were interpreted to include all optical radiations in the ultra-violet, visible, and infrared regions.

In 1956, DRCL sent a team, augmented by several AWRE scientists, to make observations at Operation Buffalo, the series of tests at Maralinga in South Australia. This was the time of the first series of tests at Maralinga, and living quarters, experimental facilities, etc. were still being completed when the scientific teams arrived on site. While conditions were uncomfortable and difficult, virtually all experiments which had been planned by the DREO thermal-measurements team were made successfully. Observations were made on the shape of the thermal pulse by Dr. Carruthers and Doug Pattman with special high-speed bolometers developed by them. The thermal pulse was also recorded at lower time-resolution by radiometers, and the total heat flux by calorimeters. These instruments had been fabricated at DRCL to US designs by Dr. C.E. Dahlstrom, who also joined the team and carried out observations with them at Maralinga. The light output spectrum from each weapon burst was recorded by Glen Turner using special high-speed ciné-spectrographs. These ciné-spectrographs were specially built from a US design by a Canadian company under contract to DRCL.

The following year, 1957, a team went to the next British trials, Operation Antler at Maralinga. The team was led by Mr. Ronald Wilson from AWRE and the senior Canadian scientist was Parr Tate. The instrumentation for Operation Antler was similar to that for Operation Buffalo with the addition of a set of photocells to make observations in selected wavelength bands and high-speed photomultipliers used by Dr. Tate to observe the gamma-induced fluorescence of the air surrounding the explosion.

In all, observations were made on seven nuclear bursts. The results were analyzed and reported to AWRE.

Operation Antler was the last series of nuclear-weapon trials at Maralinga. The series Operation Lighthouse proposed for 1959 was cancelled amid negotiations leading up to a nuclear test-ban treaty.

DRCL expertise was utilized to make thermal measurements at the large conventional-explosive trials that were undertaken at SES in the 1960's in its shock and blast program. This was done using the high-speed bolometers and photocell equipment developed for atomic-weapons trials. The investigators were Doug Pattman and Parr Tate, and their observations showed that the thermal pulse from a large high-explosive burst consisted of two peaks, somewhat similar to the pulse from a nuclear burst. This was the first time such a behaviour was reported for a conventional-explosive burst. In all, thermal measurements were made on a 100-ton TNT burst in 1961, a 500-ton TNT burst in 1964, both at SES, and on a 20-ton TNT burst plus a propane-oxygen balloon explosion at Hinton, Alberta in 1966. The last two were part of the series Operation Distant Plain.

RADIAC INSTRUMENTATION

From the beginning of radiation research at DRCL it was apparent that the Canadian Armed Services were in great need of scientific (as distinct from engineering) input into their program to equip themselves with radiac instruments. Prior to the build-up of suitable expertise at DRCL, the Canadian Army, the Service primarily concerned, had encountered severe problems and even failure with projects to procure or develop suitable radiac equipment from Canadian electronics firms. However skilled the staffs of these companies were in electronic engineering they lacked experience with ionizing radiation and fell into a number of pitfalls. To mention but two, there was failure to realize that in a radiation environment the air itself becomes conductive of electricity and unless precautions are taken, sensitive detection circuits will not behave. Another, was that the responses of a detector to radiations of different energies were quite sensitive to the materials of which it was made, in particular the atomic number of the material. The task of Canadian industry in developing suitable instruments was also made difficult because suitable radiation sources did not exist in industry for proper calibration and measurement of energy response.

The situation was addressed at DRCL by hiring engineers and scientists with some experience in ionizing-radiation R&D and equipping the laboratory with a range of radiation sources. Substantive assistance was given to Canadian industry in on-going development projects. In addition, some instruments developed elsewhere underwent substantial modification, improvement, testing and evaluation to make them suitable for Canadian military use. Where no candidate equipment for improvement was available, original development at DRCL was undertaken.

The cooperation between DRCL, the Army Development Establishment (and its successors) and Canadian industry resulted in the acceptance into service of five instruments. These were:

IM-108B	High-range portable radiation survey meter
IM-5016	Low-range portable radiation survey meter
IM-5015	Fixed-installation remote radiation monitor
AN/ADR-501	Airborne radiation monitor and recorder
AN/FDR-501	Long-range, fixed-installation, remote radiation monitor

These instruments resulted from the efforts of a team whose principal members were Alex Carruthers, Arnold Henrickson, Jack Nicholls, Mr. D. Parker, Dave Benyon, Mr. P.C. East, Eric Jones and Doug Pattman.

Following the successful equipping of the Canadian Armed Services with a range of radiac instruments, work was undertaken on the preliminary development of a new generation of radiac instruments employing newer technologies; however, at about this stage the probability of nuclear war was perceived to have receded and this development program was assigned a much lower priority. Less money and staff were assigned to development and acquisition of new radiac instruments. A second-generation wide-range radiac survey meter developed under this reduced Program at DREO by Phil East was accepted for engineering development and an advanced model was produced by Canadian Industry, but it was not procured in quantity. Work also was begun on investigations leading to a solid-state dosimeter for the Canadian Forces which would indicate radiation dose from both gamma rays and neutrons. This work is still continuing.

RADIATION PHYSICS

This work was under the general direction of Charlie Clifford. Two areas were of special interest: calculation and measurement of the shielding afforded by materials and structures to humans exposed to radiation; and the amount and type of radiation deposited in certain organs of the human body.

To take the latter of these areas first, it was important to know the dose of radiation deposited in the bone marrow of a man exposed in a radiation field. The bone marrow is the principal blood-forming organ in an adult human; it is one of the most sensitive organs to radiation; and damage to bone marrow is the main cause of rapid (up to 30 days) death of humans who receive large doses of radiation. Another cause of rapid death is the dose to the gut. A program was set up to measure the dose to the gut and to bone marrow using "phantoms". (In the field of radiation dosimetry, a model or dummy used to represent the human body is known as a phantom.) Early work in the late '50s included the use of film badges as detectors by Glen Turner, and the use of condenser ionization chambers by Charlie Clifford and Alec Carruthers. Such detectors did not measure well the dose to bone marrow found in small cells surrounded by bone. Attempts were made to use smaller and more appropriate dosimeters in more realistic phantoms. For example, a wax phantom containing human bones was used with small ionization chambers. These included Sievert-type chambers with conducting plastic walls fabricated in-house, as were the custom equipments designed to charge and read these chambers. More accurate measurements of bone-marrow dose were made by Bob Wilson, who used a small chemical dosimeter based on the calcium benzoate-salicylic acid dosimetry system devised at DRCL in its Radiation Chemistry program. The chemical dosimeters were small and sensitive and gave more accurate results for dose to the bone marrow than could be achieved with ionization chambers. Both systems were superseded by the smaller and more accurate thermoluminescent detectors which became available in the '60s.

The phantom dosimetry work was continued in the 1960's and into the 1970's by Bob Facey. A much more realistic phantom had been acquired. This improved phantom consisted of a plastic shell which contained a complete human skeleton and was filled with a liquid simulating human tissue. A more sensitive thermoluminescent method of dosimetry now was available and dose to bone marrow was measured again. Measurements were made for gamma-ray and later neutron irradiation.

The work just described concerned the gamma dose produced in bones by external radiation whether gamma or neutron. It was also of interest to measure the dose deposited by neutrons at depth in a phantom. About 1965, DCBRL had developed a small proportional counter for neutron detection. This counter was much better than any commercial counter available at the time and its use enabled the dose as indicated by a dosimeter on the surface of the body to be related to the actual dose absorbed in bones within the body. Studies were made at this time of the effect of the angle of incoming radiation on the dose to active bone marrow with some interesting and surprising results.

A great improvement in the capability of DCBRL to measure dose due to neutrons resulted from work of Alan Johnson. He succeeded in analyzing electronically the shape of pulses in a irradiated detector crystal and in distinguishing between those due to gammas and neutrons. This work permitted the construction of a large radiation spectrometer.

The other area of work in radiation physics, namely, shielding was investigated extensively. Only a representative few of the many experiments made in this area over the years can be described. In the early 1960's, the transport of radiation in the air over the ground was studied using the computer built by DRTE. In those days, there were no micro-computers, the existing computers were maintained in industrial or university computing centres, and were not usually available for hands-on operation by scientists. The debugging and successful operation of a program was often a slow and painful process. The early DCBRL radiation-transport programs were programmed in machine language.

In spite of the difficulties, calculations were made and many ingenious experimental techniques were employed to confirm them. For example, small sources were deposited in a pattern on plane disks to represent a plane of contamination, polystyrene foam slabs were stacked in such a manner that a source surrounded by air could be studied on the small scale. The foam effectively scaled down the air dose by a factor of 60 or so. Extended sources of radiation were represented by a single source moved by wires or strings or hydraulically in a liquid-filled tube. Using these techniques the dose received in a trench or foxhole from contaminated ground was measured. The effect of scattering of radiation from the air above the hole, "skyshine", was also taken into account. A study was done of the effect of penetration of the lip of a hole by radiation.

DCBRL built up an expertise in radiation shielding that resulted in an international reputation. Charlie Clifford was for a number of years a member of the Radiation Shielding Committee of the US Academy of Sciences and after he left the laboratory, he was succeeded by Frank Szabo on the committee. The work at DREO (and its earlier incarnations) has become classic and now is incorporated into standard shielding handbooks.

The highly sophisticated (for its day) radiation-transport computer program known as 05R was obtained by DREO and adapted to run on the new CRC computer. This was a modern main-frame computer much more capable than that used in early work. The 05R radiation-transport program made it possible to do detailed calculations of radiation fields arising from both neutrons and gamma rays. The studies included transport of radiation down ducts with bends, and calculation of the radiation scattered by slabs of various materials. The mobile spectrometer constructed at DREO using Alan Johnson's circuitry made it possible to verify the calculations experimentally.

The shielding afforded by an armoured fighting vehicle to its crew under irradiation from a nuclear weapon was calculated taking both gamma rays and neutrons into account. Principal investigators were Frank Szabo and Alan Robitaille. Dr. Robitaille later made field measurements in a Canadian tank exposed to neutrons at a US facility in order to confirm the results of these calculations.

Frank Szabo studied the propagation of neutrons in air over ground in the range of a few hundred meters. Calculations by computer simulation were confirmed by experimental measurements using the DREO van de Graaff accelerator as a source.

RADIATION CHEMISTRY

One of the first areas investigated in radiation chemistry was that of chemical dosimetry. Doug Grant was one of the first investigators at DRCL. He devised a system using a leuco compound which was colourless in solution but formed a blue triarylmethane dye by reaction with hydroxyl radicals produced under irradiation. The blue dye could be measured in a colorimeter to give a good indication of dose. He then came up with a more sensitive system using a solution of calcium benzoate which produced salicylic acid under irradiation. Readout was simple. The calcium benzoate was non-fluorescent but the salicylic acid fluoresced brightly under ultraviolet irradiation. The concentration of salicylic acid, and thus the dose, could be measured in a fluorometer. The system was sensitive to a little as one-tenth rad of radiation. It was used in phantom dosimetry studies at DRCL and has worked its way into standard experimental technology. It is used by many radiobiologists for monitoring exposure of animals to radiation.

More fundamental studies in radiation chemistry were also carried out. An attempt was made to detect free hydroxyl radicals in irradiated water directly using an electron paramagnetic resonance method by Marcus Weinberger. It was not successful, however, because radical concentrations proved to be below the limit of detection.

Later, studies were done by Jack Purdie of the radiation chemistry of thiols and disulphides. This work was of interest in illuminating the mechanism of action of chemicals which when taken into the body can protect from radiation damage. Most of the radioprotective drugs are thiols which form disulphides in the body. The disulphides are thought to be the species which actually protect by providing a reaction pathway to discharge any free radicals produced.

RADIATION BIOLOGY

The earliest work in radiation biology was begun by Paul Vittorio at DRKL. He studied the changes in metabolism of slices of rat liver which occurred as a result of exposure to radiation. After transfer of this work to DRCL, he used the method of ^{51}Cr uptake to measure changes in activity of various organs in rats exposed to radiation. The ^{51}Cr was injected into the subject animals and its incorporation in various tissues was used as a measure of their activities. ^{51}Cr is radioactive so that its concentration in tissue can be readily determined using a radioactivity counter.

Other work in radiation biology concerned the search for radioprotective agents, that is, compounds which, when injected into troops, would protect them to some degree from subsequent exposure to radiation. The work, under the direction of George Grant, was closely coordinated with similar work in other allied nations, particularly through cooperation with the Walter Reed Army Institute of Research (WRAIR) in the United

States. Various candidate compounds were tested by injecting them into mice, exposing the mice to various doses of radiation, and observing the survival rate of the mice. Jack Purdie studied the effect of radioprotective agents on irradiated cells in tissue culture.

Some of the compounds tested were obtained by exchange with WRAIR and other allied laboratories but many were synthesized at DRCL. Both previously-known and new compounds were made. Keith Shaw synthesized a series of thiosulphate compounds for this work while others were produced under contract at the Ontario Research Foundation. The compounds were screened for their radioprotectivity, the promising ones being subjected to more detailed evaluation. Over twenty papers were published on radioprotective compounds.

Although most of the work in biology concerned radiation, DRCL staff also advised the military on other aspects of the biology of nuclear-weapon effects. A trial to assess the injuries to troops caused by their being violently moved and injured by the blast from a weapon (translational injuries) was carried out by the Lovelace Foundation, under contract to DREO. Dummies were placed in locations of high blast at the large conventional-explosive trial (Operation Miser's Bluff) in the United States in 1970. Results were analyzed and reported at the Dial Pack Symposium in 1971. The results of this work were incorporated into a Standardization Agreement on the effects of nuclear weapons on personnel.

Following the retirement of George Grant in 1975, the work in radiation biology came under the direction of Alan Cairnie. The thrust of the work changed to the study of radiation-induced vomiting. After high, but not necessarily lethal, doses of radiation a human vomits and if this occurs during certain military tasks it can render the man militarily unfit. Knowledge of the causes of radiation-induced vomiting and of possible means of preventing it are militarily significant.

Studies of the vomiting reflex were carried out by Alan Cairnie using the rat as an animal model. The rat does not actually vomit but does avoid a particular food which has caused it apparent discomfort or with which it associates an unpleasant gastric effect which is analogous to nausea and vomiting in humans. Rats were fed saccharine-flavoured foods and subsequently irradiated. The degree to which they subsequently avoided such a food was studied as a function of the amount of radiation received. Certain drugs were tested to determine to what degree they decreased this effect in rats, to indicate if they might be vomiting protective.

The work on vomiting was continued by Kent Harding. He worked with dogs which do vomit and therefore were expected to be a better model of the human than was the rat. The sensitive organs which are responsible for radiation-induced vomiting also were studied and promising compounds for reducing this effect were identified.

ION PHYSICS

There were two aspects to the program on ion physics: a study of the theory of ionization chambers themselves; and studies of some basic properties of ions. and their behaviours in irradiated gases.

Methods for calculating the current in an irradiated ionization chamber had been worked out in the era prior to World War I. However, improved knowledge of ion properties and the availability of computers for checking the accuracy of approximate analytical solutions warranted another look at the subject. Parr Tate, assisted by Gerry Berlinguette, carried out calculations of currents in a plane-parallel ionization chamber, taking diffusion of ions into account. Dr. Tate, assisted by summer research assistants, evaluated the accuracy of approximate solutions for currents in ionization chambers which were in use in the health-physics field, and studied the saturation curve in cylindrical and spherical ionization chambers and carried out experimental measurements to confirm the theory.

Sid McGowan measured the mobility of ions and their recombination coefficients in laboratory air. This provided the information necessary for the design of practical ionization chambers. Most previous work had been done with carefully purified and dried air and did not necessarily apply to practical ionization chambers in actual use in the field.

Bev Young and Arthur Johnson measured the attachment coefficient of electrons to oxygen in an irradiated gas using a microwave method for determining the electron concentration in the gas.

Inevitably, unsuccessful experiments also were undertaken: Tate's attempt to measure the electron attachment coefficient for oxygen directly, in an apparatus built specially for this purpose was never successful and the measurements were done by others elsewhere; McGowan's attempts to observe the cyclotron resonance of ions in a magnetic field in an experimental chamber also did not succeed. It turned out that the magnetic field and chamber were not large enough to observe this effect.

THE CHEMICAL DEFENCE PROGRAM - 1941 TO 1982

by

Jim Norman

BACKGROUND

The original mission of DREO had been to operate Canada's chemical defence program. In the years before WWII, the fledgling program assessed information needs and ensured that necessary technology was imported. During WWII, it developed a cadre of experts, it conducted R&D on chemical warfare topics, it developed and oversaw the production of chemical protective clothing for the Canadian Army, and it constructed and operated a manufacturing plant for chemical warfare agent mustard to produce sufficient agent that Canada would have a credible retaliatory capability. After the war, it oversaw the demolition of this plant, the disposal of the agent, and disposition of surplus protective equipment. It also continued its R&D program, but at the much-reduced level appropriate to peacetime.

The perceived threat of those years was that from toxic agents known from WWI and the inter-war years, principally from mustard (and its very close relatives), from phosgene, from the volatile cyanides, and some arsenicals. Work during WWII, therefore, was directed to ensuring adequate protective capability of Canadian CW protective equipment against these materials. A fraction of the work also was devoted to searches for new toxic materials that might prove to be CW agents and for which defences might be required. Materials investigated included arsenical vesicants related to Lewisite, nitrogen mustards, toxic gaseous materials related to arsine and stibine, and some sulphur-fluorine compounds. This work centred on detection of such materials, determinations of their toxic effects, and on means of protection against these potential agents.

Post-war work at first was directed towards "cleaning up and closing out" the wartime activities, however the surprising information on the wartime German chemical program which revealed two series of highly toxic chemicals with high potential utility as CW agents, the G nerve gases and the fluoroacetates, provided a new impetus to, and added a new scope and direction for, the program. One of the earliest projects was to make enough of these materials to examine their properties. Work on fluoroacetates was contracted out -- that on G agents, the phosphonofluoridates (called fluorophosphonates in those days), was handled in-house. The easy cooperation of wartime among Canada, the UK, and the USA was recognized as an effective way of conserving national resources and was utilized to permit a wide-ranging program to be mounted by a coordinated Collaborative International Effort, and soon a joint Canadian, British, and American Program* on synthesis of organo-phosphorus compounds was in full swing. This synthesis program had two aims: firstly, to study and understand the chemistry of phosphorus and its halides, their reactions with organic reagents, and the reactions of the organophosphorus compounds themselves; and secondly, to study the relationships between structure and toxicity of organophosphorus agents. This involved the synthesis of whole series of homologues and analogues of toxic materials, separation of isomers, etc. Again, Canada carried her share of the load. Other projects were soon added to this joint program: to assess the effectiveness of current procedures and protective equipment, to discover ways and means of detecting and/or identifying these materials, to study chemistries which would lead to effective decontamination, to study highly toxic natural products, to investigate the modes of biological action of all toxic materials capable of becoming a CW agent, the relationships between dosage and symptomology, and to determine the behaviours of these materials in the field so that hazards and their potentials for use as CW agents could be evaluated.

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* Experience with this joint program brought out two main requirements for success. Firstly, all the results -- successes, failures, maybe's -- of the experimental work had to be made fully available to all the participants. Secondly, the bench-level scientists conducting the work had to be given every opportunity to meet and talk, to visit each other, and to engage in full discussion without hindrance from national security considerations, to plan bench-level cooperative experiments, and, if need be, to participate directly in the experimental work in the laboratories of their colleagues in the other nations.

DREO was assigned responsibility for Canada's efforts in searches for new agents, methods for synthesis of agents, for purification of agents, for detection, identification and analyses of agents, for individual protective equipment against agents, for decontamination of agents on the individual, for some aspects of agent toxicity and for toxicology studies, for some aspects of prophylaxis and therapy for agent poisoning, and to advise and assist all other participating agencies (Canadian and foreign) in the overall chemical defence program.

An essential first step in the whole program was an assessment of capabilities of available equipment against the new threats and, in most instances, these capabilities were found to be very low to non-existent, hence a full-scale program was needed to fill all the gaps revealed. This had just been mounted when the British informed their Allies that, following up on a lead from a research laboratory studying organophosphorus insecticides in which it had mentioned that certain compounds were "too toxic for use as insecticides", they had found a new class of organophosphorus nerve gases, the so-called V agents (the S-(dialkylaminoethyl) alkylphosphonothiolate series). These V agents, while being more toxic than G agents, also possessed the property of entering the body through intact skin. It was no longer enough to protect the body by protecting the respiratory passages with a mask, now the whole body had to be protected from contact with agent. Other implications were that: detection techniques required improvement by about an order of magnitude to respond to the much smaller amounts of material that could seriously incapacitate or kill a person; cleaning of all traces of material from skin or of neutralizing it in situ within a few seconds now was mandatory; impermeable materials to protect hands and feet so that the soldier could carry out his military duties on contaminated ground were essential; and, of course, investigations of the full range of toxicity-structure relationships, biological modes of action; medical, prophylaxis and therapeutics studies, and field behaviour were required again.

The program that was mounted at DREO included the following elements:

- Synthesis and Characterization;
- Detection and Identification;
- Automated Detection of Agents;
- Decontamination;
- Individual Protection;
- Toxicity and Toxicology;
- Medical Treatment;

applied to these new classes of agent. These are dealt with, in turn, below.

SYNTHESIS AND CHARACTERIZATION

The total, overall joint program of the three Nations was designed to seek out all aspects of the new classes of agents, their chemistries, toxicologies, field behaviour, etc. to allow assessment of their utilities as CW agents, and to assess the threat to the Armed Forces of the USA, the UK, and Canada.

Canada had accepted a major role regarding fluoroacetates, however this was a DRB HQ contracted-out program which, while of interest to DREO, obtained only miscellaneous support from either DREO or DRES. Within the wider context of Chemical Warfare, fluoroacetates did not appear suitable for any major role and, by 1958, the investigations of these materials ceased, and DREO was no longer involved in any way.

For organic phosphorus compounds, the program included studies of the synthesis routes for preparation of the various phosphates, phosphonates, phosphites, phosphides, etc. (or of the starting materials needed) and included methods of purification and determination of physical constants; studies of reactivities and mechanisms of reaction; of stabilities, decomposition products etc. The program also was used to prepare materials for toxicology studies. Canada had accepted only a limited role in this part of the 3-Nation program and undertook the preparation of some 28 G- and V-agent analogues as part of the overall work. Details of this are still classified.

These classified efforts however have stood DREO in good stead. Over the years, synthesis of many other chemical series, as well as organophosphorus compounds, has continued as a major activity. A series of bis-functional oximes for mapping the surfaces of agent-sensitive enzymes were prepared. These also were, potentially, potent reactivators of agent-inhibited enzymes. A second series of reactivators of such inhibited enzymes, the hydroxamic acids, also were prepared. Many potential radioprotective compounds were synthesized to support the sister program on radiation biology. Finally, the synthesis program carried out, and still carries out, routine preparation of very-high-purity agents to support all other chemical defence activities, and also synthesizes small quantities of toxic materials not otherwise available, to support various lines of research.

DETECTION AND IDENTIFICATION - CLASSICAL TECHNIQUES

Detector Papers for Liquid Agents

The capability for detection of CW agents in the field by the military by the end of WWII included detector paints, papers, and powders containing B1 dyestuff (a near-universal detector for organic liquids) and camouflage pigments (to attain the usual military olive-drab colour) for issue to the individual soldier. The detector paper was intended to be attached to him to inform him when he had become contaminated with liquid agent, the paint was to be used on gas capes, vehicles, and armaments so that, similarly, he could tell if his immediate surroundings and weapons systems, vehicles, etc. were contaminated, while powder could be sprinkled on the ground for the same purpose. Detector kits with a wider range of capabilities, to detect agent vapours as well, and to distinguish among the various classes of agents (type-classification) were available at a slightly higher level, on issue at the company level. Kits for assessing the safety of drinking water and food supplies were on issue at the unit level.

A range of experimental detector papers to distinguish among various liquid agents also had been developed. These were not based on B1 dye -- instead, they relied on colour-change reactions, analogous to the "spot tests" of elementary qualitative analytical chemistry. While production plans had been drawn up, these papers had not entered into service by war's end.

Wartime detector papers for liquid agents did not require a differentiating capability. All liquids had much the same toxic properties -- a vesicant effect upon skin and eyes and as a source of vapour to pose a respiratory hazard. With the advent of the two classes of nerve agents, liquids now posed several different hazards. Liquid mustard penetrates almost all materials to reach the skin below and produces skin damage which is long-lasting (a man could be a casualty for weeks) but which is fatal only under exceptional circumstances. G agents are volatile and evaporate off skin rapidly and pose little liquid hazard, except when, mistakenly a decontaminating ointment is used. This serves to trap the liquid in the ointment grease base and prevent evaporation. Agents then enter into the body through the skin. Liquid V agents penetrate skin rapidly so that toxic (indeed, lethal) doses can be absorbed in as short a time as 30 seconds. A detector system to tell the soldier of the nature of the liquid and, hence, of the hazards posed to him now was a new requirement. The experimental detector papers became the basis of a highly successful R&D effort to develop a detector paper which differentiated among the various liquid-agent classes. This eventually became the Paper, Chemical Agent Detector, 3-Way, Liquid, known less formally as Canadian 3-Way Paper.

Studies of solvent and acid-base properties of the various liquid agents showed that liquid mustard and liquid G agents were both highly polar neutral liquids but had quite different abilities as solvents for many complex organic dyestuffs. V agents were highly polar liquids but also were basic, and their presence could be shown by an appropriate acid-base indicator. These factors served as the basis for differentiation of the various classes of liquid agent. Some other factors of importance were that the dyestuffs affected by each liquid class produce readily distinguishable colours from each other, and that all materials used had to be insoluble in water, to allow for paper manufacture.

A red dyestuff with high solubility in mustard and almost no solubility in G or V agents, a yellow dyestuff similarly specific for G agent liquids, and a V-agent sensitive yellow-blue acid base indicator were discovered, all water-insoluble, and from which a detector paper could be made. The principle was simple. Dyestuffs ground and sized to the proper particle size (not too large, not too small) were mixed and then incorporated into a paper web. When contacted by the liquid the particular dyestuff would pass into solution to colour the liquid and this dyed liquid then would wick out onto the paper to produce a large, visible, coloured spot which was about 10 times as large as the original drop. Mustard produced blood-red spots, G agents produced yellow to orange spots, while those from V agent were dark green to blue-black. Some of the technical problems which had to be solved included development of a large-scale synthesis method for the water-insoluble acid-base indicator. Up until this time, it had been a lab curiosity and only a few grams had ever been made. Now ton quantities were required. Dyestuffs had to be prepared for incorporation into paper. This involved reducing bulk material to a very fine particle size, and included studies of grinding, of screening out oversized and undersized particles, and studies of wetting and redispersing agents.

The paper itself was the subject of much development, to formulate one with appropriate thickness to carry the dye system, with sufficient strength, which was water repellent but not oil repellent, and which provided very fast response to agent and with a large enough amplification factor for fast, easy visibility of small agent drops. Later, an adhesive layer was added for easy attachment to the soldier's uniform, or the vehicle, or weapon.

Three-way Detector Paper remains one of DREO's most successful developments. This item is standard in the Armed Forces of all of the NATO and ABCA armed forces and with those of seven other friendly-neutral Nations, and has become a regular product of one of Canada's leading chemical specialty manufacturers.

Expertise developed in making this paper led to development of three other detector papers, two for training, to detect different types of liquid training agents; and one developed for use in field trial assessments. This last was then further developed into an operational detector paper for the US Army, which, similarly, has become an item of commerce for Canadian industry.

In the same way, experience with the differential dyestuff system was used to develop replacements, with differentiating capabilities, for the older detector paints and powders. There is little call for these items now. All their roles can be handled by the new detector paper.

Detection of Nerve Agents in Water

Incidents of poisoning of Canadian troops resulting from use of local water supplies during the Korean police action confirmed the need for a kit for screening of water in the field. Simple tests were needed to show dangerous quantities of known water poisons, and of chemical warfare agents. By 1952 a field kit for testing water had been developed for use by Field Units, by the Unit Medical Officer and by the operators of water points in the Field Engineers organization. This kit had tests for toxic heavy metals, for cyanides, and for mustards, but, of course in that era, lacked a test for nerve agents, now a requirement. An article in an American scientific journal gave us a lead for such a test. This was based on the inhibition of a catalyst by nerve agent so that a normal, easily-detected reaction could not proceed. This, of course, is a reverse-detection technique, the absence of agent being detected, thus indicating the safety of the water. A stabilized acetylcholinesterase enzyme preparation was developed which was used to prepare a wettable but insoluble enzyme spot on a test paper. A hydrolysable substrate prepared as a separate stable tablet was added. If hydrolysis occurs, the hydrolysis product is oxidized (oxidizer was included in the tablet) to a very-easily-distinguished coloured material which precipitated onto the enzyme spot, and produced a strongly-coloured spot. If agent is present, there is no hydrolysis and no coloured spot. If the test paper changes its colour, then nerve agent is not present.

The development work went on in two stages, the first to give the Forces an immediate test capability, the second was to optimize stabilities, sensitivities, materials used, storage packages and the many things needed for a long-shelf-life military item. By 1960, the first stage had been completed and, by 1964, the second was accomplished. This kit remained as a standard kit with the Canadian Forces until 1986.

Detection of Nerve Agent Vapours in Air

By 1960, all NATO countries were working on methods for detecting G and V agent vapours in air. Many nations were attempting to concentrate agent vapours out of moving airstreams using collecting materials such as activated silica gels or activated alumina powders, followed by chemical spot tests, but soon it was found that stoichiometric colour tests were one- to two-orders of magnitude too insensitive for detection of even dangerous amounts of agent. While Canada also examined such techniques, it was not for the development of detection techniques -- rather, it was to develop sampling techniques suitable for use in field trials, and which were to be followed by analysis in a fully-equipped laboratory. Our work concentrated on modification of the enzymatic system previously described for detection of agents in water. Modification into a vapour-test device was relatively easy. The difficult part was in development of packaging which would guarantee adequate sensitivity and stability for a reasonable operational life in the field and which would have adequate strength for issue to individual soldiers. All of the problems were overcome and a small cheap device, the nerve agent vapour detector was developed.

A crisis developed in Europe in the early '60s and, in response to an urgent military request, DREO undertook the manufacture of 10,000 of these detectors for the Army from its development tooling, and these were issued in 1962. Technology then was transferred and manufacturing was done by Canadian industry. This item is still being manufactured in Canada to supply the Canadian Forces. It also has been acquired as standard equipment by the Armed Forces of five of our Allies. Problems with its ongoing manufacture arose, were met, and the item continues in service. These problems are described below.

Redesign of the Nerve Agent Vapour Detector (NAVD)

In the early '80s, the agent-sensitive enzyme used in the Canadian NAVD was taken off the market. A feverish search was mounted to find a replacement enzyme, commercially available, with correct sensitivity, selectivity, etc. A suitable source of an enzyme from electric-eel organs was found but its use meant a re-optimization of the detector -- possible new support papers, new stabilizers, new buffers, etc. Fortunately, the support papers, the substrate and the outer packaging did not need to be changed, however a new buffering system had to be developed. A modified vapour detector was manufactured, and accelerated storage trials indicated the shelf life to be about as long as for the original detector. At the end of this re-development, a new NAVD was available. Its sensitivities, storage life, and use-parameters were essentially unchanged from the older detector. Indeed, all the changes were transparent to the soldier.

The C2 Kit

The Canadian Forces needs for detection and type-classification capabilities greater than those possessed by the individual soldier had been satisfied in the 50s and 60s by use of the American M18 kit. This kit had been modified in 1966 to a Canadian version (M18A2Cdn) by substituting the Canadian nerve agent vapour detector for the American nerve agent detector device. In the same year, a major study of detection reactions was undertaken. A detailed examination of the chemistry of detection of non-nerve-gas agent vapours was carried out and it was soon realized that almost all war-gas vapours could be detected with a common reagent, but using different colour-developing reagents. Following on, a project to develop a simple kit with adequate sensitivity to detect and type-classify all war gases assigned Priority I by NATO was started. The key to this work was design and development of a special hand-operated pump for generating high differential pressures across a novel sampling head. This head involved sampling through either of two ports -- one for detector tubes to detect vapours of mustards, cyanides, phosgene, phosgene oxime and a second port for nerve agent vapour detectors for G and V agents. This second port incorporated a critical orifice (which required the high differential pressure to operate) which increased detection sensitivity by two orders of magnitude. This allowed detection of the very low concentrations which produce miosis -- a symptom of nerve agent exposure which seriously degrades visual acuity -- an essential capability for control of this symptom. It also gave, for the first time, a field detection-capability for agent aerosols (important for V-agent detection). The work was successful, the kit was developed, and then adopted by the Canadian Forces in 1974. It was (and still is) the only kit ever developed which met fully the very stringent NATO specification for such a device. It remains an item of commerce and is still in service with the CF, and has been adopted by Australian and New Zealand Forces.

DETECTION AND IDENTIFICATION - AUTOMATED TECHNIQUES

While vapour detectors, detector papers, and detector kits are worthwhile, they all require conscious decisions to initiate their use, they require training of operators, their use consumes time and manpower, and they do not provide a readout. Commanders must interpret the information from these detectors and then issue appropriate orders. Military preference is for devices that can be turned on well in advance of the need, that consumes little power or other supplies, that require little training for use or for maintenance or for servicing in the field, and which compares the output with pre-set criteria and which automatically sounds an alarm either when hazard is still some distance away (remote alarm), or when actually present (local alarm). All ABCA and NATO Nations have R&D programs to develop devices to satisfy the military's preferences.

Agent when dispersed from an attack usually is seen as a liquid on surfaces, or as liquid drops falling through the air, or as a fine-drop aerosol sustained by and moving with the local air currents, or as a vapour cloud in the air, moving as the wind dictates. Programs to detect and warn of such conditions have been large parts of American and British detection R&D programs. Canada, in consultation with these close Allies, had mounted a much more limited program. In the early '60s to mid-'70s, Canada's efforts included development of a device for local warning of falling drops, the Liquid Agent Detector and Alarm (LADA), and somewhat later, a device for remote detection of agent vapour clouds moving in the wind, the Correlation Interferometry Chemical Agent Detector and Alarm (CICADA). Still later, in the '80s, R&D was conducted on means to turn a UK-developed device for monitoring chemical-agent liquids on surfaces, the Chemical Agent Monitor (CAM), into an automated alarm for airborne vapours. The new Canadian device, first called Chemical Agent Monitor/Chemical Agent Detector and Alarm (CAM/CADA) and later, Chemical Agent Vapour Detector (CAVA) is described by Charlie Clifford under the Protective Sciences Division write-up.

Liquid Agent Detector and Alarm (LADA)

LADA grew out of a soon-realized deficiency of 3-Way detector paper (indeed, of all detector papers of that era); that it was difficult to use at night. Any liquid agent stains that could be seen under night-sky illumination (mainly moonlight) were large and almost invariably associated with gross contamination and extremely high hazard levels. The small stains associated with small agent drops and low contamination densities typical of the lowest hazard levels that need be detected could not be distinguished, unless a strong white light was used. At night and on the battlefield, the Military will not accept use of white light, preferring to use the much-less-noticeable red light, but this light does not allow adequate visual detection of the stains. One solution was to develop a fluorescent-dyestuff-loaded detector paper which could be illuminated with UV light (not visible on the battlefield). Such a system was developed. Agent stains stood out as brightly glowing spots on a just-noticeable fluorescent background and were readily distinguished in the dark.

This served as the first approach to an automated detection surface based on detecting the increase in emitted fluorescent energy as it was wetted by liquid agent. A simple optical reduction of the detector surface to a small spot image and measuring the apparent brightness of the spot vs agent applied showed the feasibility of the system but also showed that the system was not sensitive enough to small agent drops and low contamination densities to detect the threshold levels required. One effort to improve the system was based on rotation of the detector surface under a scanning head to resolve electronically-averaged signals from background noise and then amplify them until an appropriate fine-drop sensitivity was obtained. This approach worked and a prototype instrument was built which met all the stated military criteria. Unfortunately, the technology of uniform detector paper manufacture could not be transferred to industry. Product-engineering models with the requisite sensitivity (and lack of false-alarm signals) could not be produced, and the project languished for a few years.

The project was revived with the advent of small, rugged, computer-CPU-on-a-chip units. These made it possible to program enough logic into the system and to give it a reasonable memory capacity, to allow the system to "learn". The system then could be told to "memorize" its detecting surface and to only report on change. This led to a second-generation device which recognized the beginning of an attack, and also the continuing changes during an attack, and the lack of change when the attack was over. By incorporating sensitive triggers into the device, warning and alarm circuits (lights, horns, for example) could be turned on as the leading edge of the attack was detected, remain on for the duration of the attack, and turned off when the attack had passed.

Again, a prototype alarm was built and found to be a successful detector of chemical agent attacks, however, before the alarm could be manufactured and put into production (and thence, into service), the military lost interest and shifted their priorities to development of an alarm for vapours. This project sits in abeyance, in mothballs, however it is available if the CF should decide that it has a role in their NBC defence operations.

Correlation Interferometry Chemical Agent Detector and Alarm (CICADA)

This was Canada's only venture into remote detection of agent vapour clouds. It involved duel-beam spectrophotometry, one beam being a long optical path in free air, the second beam being much shorter and containing a reference material. Absorptions over a specific spectral region in the two beams are measured and then correlated. If there is correlation, then a material with spectral characteristics similar to those of the reference material must be present in the free air through which the long optical path lies. Success as a detector of agent vapours then depends on how well the reference material matches (spectrally) the agent or class of agent.

Our first studies were to discover films with spectral characteristics (in specific regions) similar to those of agents, and a series of polystyrene and polyethylene films were found to be suitable. Work then proceeded on the optical bench. A transparent chamber was developed which could contain agent and through which the long optical path could be folded a multitude of times so that correlations could be studied. This demonstrated the feasibility of the system and much development effort was put into optimizing the optics, the mechanics, and the electronics of the system to achieve sufficiently high sensitivity to detect dangerous quantities of agent vapours. This optimized model was then put to Industry to apply engineering development techniques which would lead to pre-production engineering approval models. Unfortunately, the only model returned to us did not have the characteristics of the prototypes - the integrity of the optical bench had been destroyed and alignment (and keeping in alignment) became a major problem. High sensitivity to agents was not achieved.

The model was to have been returned to the manufacturer for re-design but, as with LADA, the military shifted their priorities to CAVA work and CICADA was not taken up again.

Chemical Agent Vapour Alarm (CAVA)

The work on this system is described later.

DECONTAMINATION

The early program at DREO in decontamination had been to improve the systems current at the end of WWII. These were designed to cope with the only two liquid agents of that era of any consequence, Mustard and Lewisite. Both were treatable with active-chlorine compounds and decontaminants of the day were so based -- calcium and sodium hypochlorites for ground, vehicles, and heavy equipment, chloramine-T in lanolin-type bases for an ointment for use on hands, face, hair, and small personal equipment, and chloramine-T tablets for water canteens (larger-volume water treatment used municipal treatment methods). Lewisite and/or its burns also were treatable with a specific antidote, British Anti-Lewisite, BAL, a di-mercaptan that complexed arsenic.

American work near the end of WWII had produced two new decontaminants: a chlorinated tri-iso-cyanurate dubbed "Decon 40", and a vehicle decontaminant called Decontaminating Agent, Non-Corrosive (DANC) -- a real misnomer. DANC corroded almost all materials that it touched: organic materials such as paint, tires, tarpaulins etc. on vehicles; clothing, hands, faces, eyes; and reactive metals such as magnesium and aluminum. From early work evaluating these American materials, DANC was rejected. It was too dangerous to people, leading to blindness if it were to be splashed in eyes, and far too corrosive around aircraft or black boxes containing electronics parts. Decon 40, however, was found to be a useful substitute for chloramine-T in skin-decontaminant systems and for impregnation of clothing for CW agent protection.

At about this time, the G and V agents were discovered and their behaviours with the decontaminants of the day were studied. The existing skin decontaminants were found to be ineffective. For G agent, it appeared that the grease base dissolved agent and held it in contact with the skin, thus permitting significant skin penetration. In some cases, the active-chlorine ingredient would react with the G agent to produce a chlorinated analogue with greater skin-penetrating abilities. The result of these two factors was to increase the overall toxicity. For V agents, active-chlorine reagents served to detoxify the agent but, unfortunately, the rate of detoxification was far too slow to prevent V agent poisoning. Such ineffectiveness provided a major impetus to studies of decontaminants. These studies could be divided into three parts: studies of chemistry to find new, powerful, reactive entities which would detoxify agents; studies of decontamination of skin, hair, etc. of the soldier; and studies of large-scale decontamination, of vehicles, major armaments, of ground and terrain. All of these studies overlapped - highly reactive chemical decontaminants must not be hazardous themselves nor could their reactions with agents be pyrophoric or explosive; decontaminants for large-scale operations had to be used by men and could not pose any extraordinary hazard; skin decontaminants must react fast enough and thoroughly enough to reduce skin-agent contact hazards to near zero before agent poisoning occurred.

Studies of Decontamination Chemistry

It was soon found that chemical decontamination of the new agents could be achieved by powerful nucleophiles through hydrolysis, chlorination, etc. reactions, or by powerful oxidants such as active-chlorine compounds, peroxides, etc., in either aqueous or non-aqueous media. Much work was done in this area with no practical payoff. All these systems proved to be unsuitable because of their corrosiveness to skin, eyes, clothing, and military hardware. Even the DS2 decontaminant for vehicles, developed by the US Army and adopted by the Canadian Forces, was too damaging to skin and eyes except under tightly controlled conditions of use.

Oxidation of agents as a means of decontamination was studied using a variety of powerful oxidants: peroxides, perphosphates, permanganates, chromates, and persulphates, as well as several active-halogen oxidants such as the old standbys: chloride of lime, javex, supertropical bleach; the more recently developed "onium" compounds from succinimides, hydantoins, etc, and a series of "iodonium" complexes. All shared one characteristic: when used in amounts to be effective, intensely exothermic reactions occurred which led to heat build-up, fires, and explosions, and such reactions were judged to be suitable for use only under special circumstances.

Decontamination of Skin

Considerable work was done in this area using active-chlorine ingredients in base creams and ointments but no satisfactory chemical-based skin decontaminants were found. The physical removal of chemical agents from skin then was substituted for chemical destruction. One of the earliest of these removal formulations tried was a finely-powdered activated silica-gel dispersed in a volatile solvent. In this, the solvent provided a "bridge" to move agent contamination from skin to the activated powder, where it would be very tightly retained. The volatile solvent then would dry and leave a dry powder (by now carrying almost all of the agent) which could be removed from the skin by simple brushing, taking the agent with it. This technique was successful and provided protection against large amounts of liquid agent on the skin. It was non-specific and removed any liquid agent, mustard, G agent or V agent, equally well. In the field, however, there were practical problems. Routine use on the skin dried the skin too much; erythremas developed, much like those from low-level burns. Also, solvent trapped under the mask became a problem when used to decontaminate the face. Residual liquid and solvent vapour led to eye irritation and eventually to nausea and vomiting when breathed for any length of time.

These studies did show that physical removal was a feasible means of decontamination of skin, and did identify some of the difficulties to be overcome. Those associated with solvent were overcome by eliminating solvent. Fullers earth, a mildly active bentonite clay widely used in the ceramics industry, could be used without solvent and was found to be about as effective as silica-gel powder in removing liquid from skin but had almost no effect on the skin itself. This was developed into a practical device for the CF, the Fullers Earth Decontaminating Mitt, and standardized. It is still in service but is in the process of being displaced by the newly-developed Reactive Skin Decontaminant reported below.

In the late 60s, it was proposed that a personal decontaminant that had the ability to penetrate dermal layers and neutralize agent that had begun to penetrate the body would be of benefit, and two investigations were mounted to explore this concept.

In the first, a well-known skin penetrant, DMSO, had been found to act as a carrier for many dissolved materials, rapidly transporting them through the skin and into the bloodstream. It was thought that this offered an alternate first aid/self aid procedure for nerve agent poisoning by having DMSO carry an appropriate decontaminant into the skin to neutralize agent before it began to effect its toxic actions. Studies showed that several oximes which were harmless in the body were powerful neutralizers of agent and the whole concept of use of solutions of oxime in DMSO as a wipe-down decontaminant for nerve-agent contaminated skin was looked at. Unfortunately, it was found that the DMSO solvent entered the skin layers much more rapidly than it carried in the oxime, and then picked up the agent and transported it away from the oxime and into the bloodstream where its toxic effects were manifested almost immediately, and death soon ensued.

In another study, freshly-prepared short-lived coordination complexes of oxime with ferric ion generated in a mixed aqueous/organic solvent were found to be capable of back-extracting agent from skin by forming a different, stable, non-penetrating complex. In animal experiments, the freshly prepared complex solution was a successful wipe-down decontaminant effective against H, G- and V-agents. It reversed early symptoms of poisoning and provided protection against multiple doses of toxic agent.

While the material was a highly successful decontaminant, it failed from the practical point of view -- no packaging system could be devised which would deliver a freshly-prepared unstable-complex solution to the skin when required.

Area-, Vehicle-, and Armament Decontamination

For any large-scale decontamination of an area or of a major piece of equipment, the current system is essentially unchanged from WWII. A slurry of supertropical bleach is prepared and scrubbed onto the equipment and the whole is let dry. The dried film is white and, in the field, usually it is washed off before the equipment is returned to Operations. This system is time-consuming and manpower intensive but is effective on most heavy equipment. It is too corrosive for use on aircraft (aluminium bodies) or on electronic equipment.

R&D activities have concentrated on finding decontaminating materials which require little time or effort and which are gentle enough for use on a wide range of military equipment. Two materials have been looked at extensively: Fichlor, a UK development based on sodium dichloroisocyanurate which is made up in water and then is a gentle, buffered, aqueous decontaminant that can be sprayed on contaminated surfaces. To be effective, however, much scrubbing is required. The material can be used on aircraft (although there is some slight corrosion) hence this decontaminant system is preferred by Air Elements. The other material is a West German emulsion. this contains calcium hypochlorite emulsified in perchloroethylene/water. The active-chlorine ingredient is the micelle of hydrated hypochlorite dispersed in the perchloroethylene. Claimed advantages are that it is non-corrosive because of the very limited amounts of water present; and, because of its highly organic solvent power, that it cuts through grease, oil, and CW agent films and wets crusted-on mud, dust, etc. so that scrubbing is not required. In practice, these claims could not be substantiated. It has been found to be largely ineffective, unless extensive scrubbing is used.

In general, these two are of limited applicability and are likely to be replaced by the equipment analogue of the reactive skin decontaminant described later.

Special-purpose operational decontamination, for example, of the minimum areas that need to be cleaned to allow a major piece of equipment such as a vehicle or a howitzer to be operated safely, usually is accomplished by spraying the small area with DS2, however, it is essential that the operator wear an NBC mask and CW protective gloves both during decontamination and later, when using the equipment.

Further Developments

These are reported below, by Charlie Clifford.

TOXICITY AND TOXICOLOGY STUDIES

This subject divides into two sub-areas. The first includes those studies which characterize toxicity and which relate to: determining the toxic mechanism and identifying the biological or biochemical lesions involved; determining the doses required for various toxic effects by the different routes of administration; determining signs and symptoms of toxic effects and symptomology progression with either time or dose, or both. The second includes activities relating to combatting toxic effects and usually is covered under medical aspects. Such studies include means to repair biochemical lesions, effectiveness (overall) of self-aid/first-aid/medical-treatment drugs and protocols, and symptomology treatment.

DREO has participated in all of the above types of study at one time or another. Some of its earliest work included extensive investigations of these topics for the standard G and V agents and also for the approximately 28 experimental G and V agent variants synthesized as the "SB Compounds" in the mid '50s. For various reasons, this work cannot be reported in any detail.

In the mid '60s, a study of the toxicity of an organo-phosphorus material coded EA1356 was undertaken. This material had unique biochemical properties and it was thought that a knowledge of its toxicological mechanism would help unravel some of the mystery associated with toxicity of the standard nerve agent, GD, and the inherent inability to reverse its biochemical lesion. These studies involved development of techniques for sampling blood at specific locations, for example arteriopuncture, venipuncture, and punctures of the left or right ventricles of the heart; and for isolating and investigating the various "esterases" in blood, for example, true acetyl-cholinesterases associated with blood erythrocytes, pseudo-cholinesterases associated with blood serum, and serum ali-esterases which could serve as cholinesterases if required. The studies of effects of EA1356 on these separate enzyme systems did identify a unique breakdown mechanism for the biochemical lesion, and the work did provide an explanation of the toxicologies of both GD and EA1356.

Other toxicology studies were carried out on materials which were not G or V agents, but were highly-toxic materials of natural origin from blue-green algae. Some blue-green algae produce complex materials which are highly toxic to mammals and which tend to keep them out of the food chain. DREO's project included studies on culturing and growing such blue-green algae and on extraction of the toxic moiety from the algae or from its habitat. These studies were not well advanced when the biologist conducting these studies left for other employment and the project was allowed to lapse.

NATURAL PRODUCTS STUDIES

As well as studying materials from blue-green algae, DREO also undertook studies of "clam poison", a natural product later known as saxitoxin. The clam-poison project went on for some years. It had been known that clams filtered out and consumed vast quantities of the marine organisms known as "the red tide" from the colour of the sea during their bloom period. It also was known that the clams themselves then became toxic to humans during this period. A US Army contract had resulted in the gathering of several tons of clams contaminated with the toxic material and from this material it was established firstly, that the toxic material was concentrated in the clam siphon, and secondly, that the toxic material could be extracted from the siphons. All told, the US Army managed to isolate about 2 grams of the toxic material from the several tons of clams collected. Some 200 mg of a partially purified material was made available to Canada, to allow Canadian participation in elucidation of structure studies, and for toxicity studies, these being cooperative with other studies by the US Army itself, by Britain, and by independent researchers at two West-Coast universities. DREO studied the purification of the material and pioneered the application of the paper-electrophoresis technique and of the use of a special, heavy seed-test paper for paper chromatography as methods of purification of the extract. This work showed the extract to contain five substances, only two of which were toxic. Other studies included purification of fragments from nitric acid treatment and attempts of elucidate their structures. Some partial structures were discovered, but, by 1960, most of the material originally provided had been used up. In addition, interest in this project had waned and the project was allowed to run down. This project involved synthesis of model compounds for degradation studies, to identify clam-poison fragments. Much of the knowledge gained in this work was applied to synthesis of a series of cholinolytics, Parpanit and its analogues, during the '60s. These were antidotes to nerve-agent poisoning and considered for possible use by Canadian military medical authorities. Evaluation of their prophylactic and therapeutic potential was transferred to DRES, and then not pursued further.

INDIVIDUAL PROTECTION

The program at DREO for developing items for protection of the individual soldier from NBC warfare is old, originating in the mid-'30s with gas-mask and canister manufacture, later expanding into ancillary items such as mask carriers and vision-correcting devices. The program also has been active in developing protective clothing systems to complement the mask system.

NBC Protective Masks and Canisters

These are the items that protect the respiratory passages, the eyes, and skin of the face. The facepiece of the mask carries those elements required for operational use -- the eyepieces for vision, the inlet- and outlet-one-way valves to control airflow direction, the speech transmitter and the headharness to keep everything in place. The canister carries the filters which remove dangerous gases and aerosols from the airstream. Together, they make up the mask.

Before WWII, the original mask of the Canadian Armed Forces, the so-called "British Light Respirator" and the manufacturing technology for it, were imported. During WWII, it evolved into a Canadian item, very similar to, but not quite identical with its UK counterpart. This separate evolution continued after WWII. Facepiece rubbers changed; the headharness, its attachment points, and its buckles were changed; a nose cup and a much-improved speech transmitter were added, and in a major redesign, all steel components were replaced with non-magnetic aluminum. This mask passed through the stages of being designated as the "No2", the "No2 MK2", the "No2 MK2/1" and then, as the "C1", the "C2", and now as the "C3" -- its current designation.

Similar changes were also underway on the canister. The original wartime canister had been a UK design but in the mid '50s, it had been replaced by an American canister, the M11, which was interchangeable with the older British/Canadian canister. The US Army had made a major change from their M9 NBC Mask, which used the M11 canister, to their new canisterless mask, the M17, and the US offered to sell, and Canada accepted, their surplus M11 canisters at "fire sale" prices. By the early '60s these canisters had become in short supply through attrition. They could not be purchased and a canister design and manufacture operation was begun in Canada. This re-design included a switch from steel to aluminum (to continue the evolution of the non-magnetic mask) and also tackled some other problem areas. The aerosol-filter-pad's filtration efficiency and its resistance to air flow both required major improvement. A study of the fundamentals of aerosol removal from a moving airstream was undertaken and this revealed several unexpected mechanisms for particle collection -- which allowed a new aerosol filter paper to be developed by the Pilot Plant. This new filter element improved aerosol filtration efficiency by an order of magnitude, but also lowered the resistance to airflow by a factor of three to four. Continuing development work resulted in replacing "make-by-hand" procedures with new machine-manufacturing technology. This resulted in greatly increased uniformity and reliability. Additionally, all the new manufacturing technology resulted in a four-fold reduction in price of a canister.

The combination of C3 Mask/C1 Canister was a highly effective mask. It was capable of removing all war gases from the airstream, either as gases, vapours, or aerosols, and similarly, removed nuclear fallout particles to non-hazardous levels. Its protection against BW aerosols was not quite as good. To meet the needed protection standard, a hood to cover the seal of the face to the mask was required. This lowered the ambient-air aerosol-particle challenge. Such a hood is built into the Canadian CW protective garment.

In the late '50s, the design of a new mask was undertaken. One highly successful experimental mask, the DRCL 5, was a major step forward in improvement of vision, comfort, improved faceseal, etc. but it turned out to be too advanced for its time and beyond the capabilities of industry to manufacture. Sadly, plans for a new mask had to be cancelled. The Mask Improvement Program then reverted to ad hoc improvements to the existing mask.

By the late '70s it had become obvious that new gas masks were needed by all three of the TTCP partners, the US, the UK, and Canada. The UK decided to go it alone and designed a new mask, the S6, which was later improved into the S10 model, their standard mask today. The US and Canada agreed on a joint venture -- the US to design the facepiece and Canada to design the canister -- to develop a common mask for the two countries. Canada developed the C2 canister which met fully (indeed, it exceeded in most values) the agreed-on characteristics, and the US designed the XM29 mask facepiece, which failed. The US then undertook redesign and produced the XM30, which also failed. Canada had noted the failure of the XM29 program and had reservations about the XM30 mask, and to protect its own interests, had instituted a small, back-up mask-design program in case the XM30 design also was unsuccessful. This program was thrown into high gear when the XM30 failed. The US then ventured into the XM40 mask program. Canada, however, withdrew and proceeded with its own design, the XC4 mask.

The story of the XC4 and its transformation into the C4 CW Mask is continued by Charlie Clifford.

The CW Protective Clothing System

The CW Suit

CW agent-proof clothing for issue to the soldier was first prepared in Canada during WWII, in the '41-42' era. This involved the impregnation of various items of service dress, wool battledress, wool socks, cotton underwear, and cotton gloves, with active-chlorine material. These then could be worn by the soldier to protect his body on the agent-contaminated battlefield. During WWII, CWL, DREO's forerunner, prepared over 400,000 sets of such impregnated clothing.

Unfortunately, the impregnant seriously damaged fabric so that the clothing tended to disintegrate during heavy activities, and also produced contact burns on skin after relatively short wearing periods, 3-4 days. These two problems were looked at towards the end of WWII, and were carried forward into peacetime. The first approach to overcoming fabric-disintegration problems was to postpone impregnation until there was a demonstrated need for such clothing, and a kit for impregnation of service clothing in the field was developed. This kit contained a relatively mild active-chlorine compound and a waxy, oily grease base, and contained enough material to impregnate the clothing of an infantry company. In principle, the chlorinating agent was to be dispersed in the grease base and then emulsified in water, and clothing was to be impregnated using this emulsion. In practice, the system was nearly impossible to use. In the field, preparation of the emulsion was next to impossible, and even when accomplished, impregnation was very uneven. It was found that impregnating the clothing consumed the entire resources of the infantry Company for five to six days. It also was found that unevenly-distributed impregnant led to "hot spots" from which severe skin burns resulted.

In the early '60s, a new approach to protective clothing was investigated. This involved preparation of a highly air-permeable thin foam impregnated with activated (respirator-grade) charcoal and use of this as an absorbent layer beneath combat clothing. This material was found to have excellent protective abilities, absorbing all agents from air, but to be too weak and too insulative to be used as a clothing layer on its own. The material was strengthened substantially by flame-bonding the foam to nylon tricot (this also cut down on heat build-up problems by reducing the number of clothing layers) without loss of protective ability. Later, this foam was covered with combat cloth and cut and used as a "sandwich" to fabricate a combat-clothing system. This could be worn in hot weather alone over underwear as the combat clothing, or over the standard combat uniform in moderate to cold weather, or could be covered by arctic outerwear under extreme-cold conditions.

The combat-cloth outer layer could be modified to produce two distinct behaviour patterns for liquids contaminating this suit. If made repellent, the liquid agent balled up into small discrete droplets and could be easily removed by the standard fullers earth mitt, while if not repellent, the liquid agent soaked into the fabric, and wicked out over wide areas. While it was not available for decontamination, it was spread out over a much larger charcoal-filled underlying area of foam. Studies of these two parameters showed that substantial protection of the individual was achieved from either system. Better protection from G agents was achieved if the clothing outer layer was highly agent-repellent, but with V agents, better protection was achieved if the outer layer was a wicking layer. Intelligence information indicated that the major threat to ABCA and NATO forces was from G agents; hence the outer layer of the final system selected was treated to be agent repellent.

This protective clothing was found to be superior to all others. It was sturdy - it could be worn for periods of up to 28 days - and protective - still providing protection for at least 24 hr against all field-achievable liquid or vapour agent challenges. It soon became the model for the protective clothing of several other nations, eg., the USA, Belgium, Holland, West Germany, and France. Most recently, this system has been adopted by the UK for her newest protective garment.

This clothing system is still in service with Canadian Forces, however the design and development of its replacement is well-advanced. The new design retains the charcoal layer to ensure the same high level of agent protection but is changed in form, to be a tight-fitting suit much better at dissipating heat.

CW Protective Gloves

It was decided some years ago to protect the hands by provision of CW-agent impermeable gloves, and development of such gloves was undertaken by DREO's Rubber and Plastics laboratory. From their experience with both natural and synthetic rubbers as mask-facepiece materials, they rapidly zeroed in on a rubber formulation that had a very high resistance to CW agent penetration. They also developed a polymer-in-solvent solution and a dip-coating technique to build up a glove on a hand form that were major improvements in technology. Because of solvent vapour hazard, and the very high level of hazard from flash fires, this system could not be safely reduced to Industrial practice. It was then re-developed at DREO as a water-based latex emulsion. The dip-coating technique was even more successful and a strong, agent-resistant (virtually impenetrable) glove resulted. Later, a very thin glove was developed using this technology for use by medical officers as a surgeon's glove. This glove also was suitable for pilots who required a high level of tactility and flexibility in a glove.

Both of these gloves have been adopted by the CF. The original is the general-purpose heavy-duty glove, and the thin glove is for special uses.

CW Protective Overboots

These boots themselves were not developed at DREO, however much of DREO's dip-coating technology was transferred to and utilized by Industry. Conventional techniques and tooling were used to produce the basic item, then a finish outer layer was put on by dip coating, using the latex emulsion developed for CW agent resistant gloves. These boots are virtually impenetrable to liquid CW agents.

Miscellaneous Items

Spectacles

A significant number of the military, about 17%, require visual correction and wear spectacles. This fact must be catered to by any protective mask and a project to develop "respirator spectacles" was started. It was found that both placement and profile of eyeglasses sidemembers was critical to a leak-free item. Sidemembers had to be lowered on the face to lie over the hard cheekbones rather than lying in the conventional temples-area and the profiles of the sidemembers in cross-section had to be ovoid, with edges feathered out. These two features allowed the sidemember to seal to the face on one side and to the mask on the other. The sidemembers required offset attachment points to the main frames to accomplish the needed lowering and, to keep the sidemember in place, the conventional design of a hook to the ear was replaced with a full D-ring loop which fitted over the whole ear. The resultant respirator spectacles posed so little interference with the mask facepiece seal that leakage rates for spectacles wearers did not differ significantly from those without spectacles. These spectacles were found to be extraordinarily stable on the face and nearly impossible to dislodge and they were adopted as the general-purpose combat spectacles.

The Spectacles Case

An extruded case for combat spectacles with molded-in hinge and interior mounting and positioning pins was developed at DREO. As with all items designed for use in an NBC environment, the case material was highly resistant to agent penetration and the design allowed for rapid, complete decontamination of the exterior without contamination of the interior.

CW Agent Protective Casualty Bags

The fabric developed for the protective CW suit was used to manufacture a bag which would protect a casualty from effects of CW agents and which would allow him to be monitored, given medical treatment, and evacuated in relative safety back to a rear-echelon medical facility. The bag design included a very long but fully sealable side opening, transparent panels for observation, and an agent-impermeable bottom layer. While these bags are standard items with the CF, there are very few in the system. The recent war in the Gulf resulted in an order for approximately 2000 of these bags.

Nimbus Cloth

This was a specially-impregnated net which could be worn by the soldier over his combat clothing. It was formulated with a burning-composition on the netting put on and held in place by a rubber dip coating. In use, the energy of the nuclear flash initiated burning which produced a puff of dense black smoke to enclose the body. This then absorbed further energy from the nuclear blast and prevented the thermal energy from damaging the individual. In tests, this system was capable of intercepting thermal energy of up to 7 cal/cm^2, a substantial protection for the individual.

CW Protective Material

In the mid to late '60s, the military indicated a need for a cheap, throw-away CW agent resistant material that could be used for temporary protection of an individual and/or his weapons system, for covering stores, for use as temporary walkways, etc. DREO responded by developing a plastic film suitable for these uses. It was based on a mylar film (for strength) laminated to a saran layer (CW agent resistance) and then covered with a camouflage-pigmented layer of neoprene. This was fabricated in rolls 1 m wide by 50 m long which could be cut with a knife, then shaped and held together with pressure-sensitive tape.

MEDICAL TREATMENT

Much of the work relating to medical treatment of chemical-agent poisoning was conducted by DRES. DREO was involved in the search for chemicals effective in treating such poisoning. DREO studied materials for prophylaxis (medication used before exposure to the agent to prevent its effects) and for therapy (medication used after agent exposure to combat and reverse its effects).

Nerve agent poisoning, which involves shut-down of the nervous system through inhibitory effects on the essential enzyme, acetylcholinesterase, is susceptible to treatment on two fronts -- provision of a reactivator which removes the blocking moitiy from inhibited enzyme and returns it to normal operation, and treatment with a cholinergic drug (such as atropine) which habituates the nerve ending to much higher than normal levels of acetylcholine, the material responsible for nerve-impulse transmission.

At DREO, early work looked at many oximes as possible reactivators of cholinesterase, and studies soon showed that two, mono-isonitrosoacetone (MINA) and diacetylmonoxime (DAM), were potent reactivators and appeared to have few side effects. Further studies showed that these two were not very effective in reactivating human cholinesterases. British work then showed a series of salts (methiodide, methosulphonate, etc.) of pyridine-2-aldoxime were highly effective reactivators of most G- or V-agent-inhibited cholinesterases. These oxime salts have been the basis of treatment of organophosphorus poisoning, in conjunction with atropine, for the last 30 years.

DREO's next study concentrated on preparation of a series of bis functional oximes to map enzyme surfaces of the various cholinesterases and, indeed, these studies, in conjunction with American studies, revealed the differences between pseudo- and true cholinesterases and provided valuable insight into structures of GD-inhibited cholinesterases. The GD-inhibited products differ from those produced by other G agents and V agents. They "age" and, in a short time, convert to a form which cannot be reactivated. Oxime/enzyme studies showed the nature of the reactive intermediate that "ages" but, unfortunately, did not produce any leads as to how aging might be stopped. Indeed, significant improvements in our abilities to treat GD poisoning have only been found in the last three or four years.

A second line of work investigated a series of hydroxamic acids as reactivators of inhibited cholinesterases. While several were fairly potent, none were more effective than the conventional reactivators of choice, salts of 2-pyridine-aldoxime.

In another approach, several cholinolytic drugs to replace atropine in standard nerve gas poisoning treatments were studied. These included the benzilate, BZ, and a series of carboxylates, the "parpanits". Some of these were exceedingly effective in countering organophosphorus poisoning in animals when used alone or in combination with atropine and/or an oxime. Several parpanit analogues were synthesized at DREO exemplifying both major and minor changes in molecular geometry in an effort to determine precisely the configuration and substituents needed to maximize effectiveness. In 1969, however, all facets of the biochemistry program at DREO to support CW Agent prophylaxis and therapy were transferred to DRES and this project was not continued.

FIELD TRIALS, EXERCISES, OPERATIONS PARTICIPATION

Over the years DREO has participated in almost all Canadian, American, and British CW agent field trials, and in most Chemical Defence Exercises and Operations mounted by the military. DREO has supported these events by participation in detailed planning, by providing special expertise, by preparing special materials, by drafting special SOPs, by providing experts to the Observer Cadre, and by assisting in evaluation and write-up of final reports.

Some of those Exercises, etc. which have involved major DREO participation include:

Spotcheck I, Spotcheck II, Spotcheck III, Spotcheck IV, all at DRES.	-	all were to assess the hazard to Canadian troops from the CW agent contaminated battlefield and to develop and test solutions to problems identified.
Exercise ADOBE, at DRES	-	to assess all procedures developed to allow continuation of military operations in a contaminated environment.
US Marine Corps Amphibious Assault, at Viques Island, Porto Rico	-	to assess abilities of US Marines to carry out such an assault under Chemical Warfare Conditions and to assess the usefulness of USMC equipment, doctrine, and SOPs.
DREO Trials of CW agent protective clothing, at DREO and Gatineau Park	-	to test degradation of CW protective clothing following 1, 2, and 3 weeks wear in heavily-wooded terrain.

US Army Infantry Board. Comparative trials of British, Canadian, and American CW protective clothing, at Ft. Benning, GA.	-	to compare the abilities of the protective clothing systems of the three nations in protecting the soldier from CW agent contamination.
NATO comparative trials of CW protective clothing, at Vogelsang, FRG.	-	Canada was a major participant in this trial, conducted by the Netherlands, which was open to all NATO nations.
Cdn Trials of CW protective clothing, at DRES	-	A trial to qualify the Canadian CW protective ensemble against NATO operational specifications.
Exercise Vacuum, at DRES	-	A trial of abilities of a multi-national brigade to conduct military operations under intense and protracted CW conditions.
Exercise CHACE I (Casualty handling in a contaminated environment), at Petawawa, Ont.	-	An exercise designed to evaluate the abilities of the Canadian Forces medical services to conduct medical operations on the chemical battlefield.
Exercise METOXI US Army, at Ft. Carson, Colorado	-	A trial of US Army CW protective equipment, doctrine, and SOPs to allow military operations in a contaminated environment by a mechanized-infantry battalion.
Trial Mentor, at DRES	-	Development of a training circuit/training system for training of up to battalion-sized military units to operate under CW conditions.
Exercise CHACE II, at Petawawa, Ont.	-	to evaluate corrective measures adopted following Ex CHACE-I, and to re-evaluate the Canadian Forces medical services equipment, doctrine, and SOPs for conduct of medical operations on the chemical battlefield.

DREO also has had less formal participation in a multitude of field trials, minor exercises, training operations, etc. over most of its history and the list of these trials is too long to detail here.

THE PEOPLE INVOLVED

Over the years, a large proportion of DREO's staff have contributed to the overall Chemical Defence Program. What follows is a rough attempt to classify them according to the type of work that was being contributed, to advance the program. I cannot claim the list to be comprehensive. I have compiled it from memory and from a few old records.

Some of the "originals" in the game at CWL were: Jack Arnell, Jack Dacey, George Grant, Ross Harvey, Tommy King, Harry Sheffer, and from the Respirator Assembly Plant, Bill Taylor and a large number of casual staff.

The main players in chemical defence were the members of the old Chemical Warfare and Chemistry Sections of DRCL and the newer Chemical Defence, Chemical Detection and Decontamination, and Chemical Protection Sections of DREO. These included the Heads: Art McKay, George Grant, Bob Heggie, Lloyd McDermot, Bob Bannard, Jim Norman, and Brian Harrison. The staff members were: Bruno Zanette (the man always at the end of an alphabetical list, except this time), Bob Blanchfield, Harry Barber, John Bovenkamp, Harold Brownell, Ross Braun, Al Casselman, Marg Chan, Marcel Chaput, Bill Cockburn, Brian Cox, Ted Dunn, Olga Erickson, Ann Finkbeiner, Rolly Fuoco, Neville Gibson, Jim Gilpin, Ken Gillette, Marg Glassford, Roy Greenhalgh, Marion Green, Bob Harper, John Hamilton, John Hart, Larry Hart, Les Hawkins, Jacques Helie, Bill Humphreys, Bernie Larose, Ben Lacroix, Bertie Lawton, Joe Legari, G. McCarthy, Ray Miller, Bob McIvor, Rick Nolan, Jack Pagotto, Georges Paquette, Jack Parkkari, Jon Preston, Jack Purdie, Jocelyn Purdie, Garfield Purdon, Rex Richards, Marg Riches, Keith Shaw, Regina Sheppard, Vi Shore, Ollie Sturk, Herb Thomas, Gail Thompson, Gerry Vavasour, and Chris Wellington. Other contributors were: Bill Armstrong, Barb Black, Doug Grant, and Pete Farant from Radiation Chemistry; Stella (Dzuibalo) Blehm, Ivan Coleman, John Scaife, Ann Finkbeiner, Phil Little, and George Patton from Toxicology; Harry Nash, John Collyer, John Montgomery, John Clark, and Gary Giles from the Rubber and Plastic Lab; Jim Wheat, Don MacLeod, Bob Dunlop, Chuck Thompson, Joe Doherty, Doug Scharfe, Colin Hyde, Kim Dix, Bruce Delong, Denis Pichette, Sylvie Boissé, and Julie Tremblay from the Pilot Plant; Lloyd Wilson, Gaston Drew, Malcolm Dewar, Pat Cavanagh and John McAndless, from the Physics Section; Dave Norman, Wib Cowie, Adrian Ruddell, Dave Bulleid, and Jean Baillot from Engineering; the model makers Ken Young, Ray Mitchell, Garn Studholme, and Rolly Arbique; members of the physiology Studies Teams: Arthur Custance and Stan Cattroll, and, over the years, the many members of the DREO Test Team; Harry Sheffer, Adrien Leger, Ron Haines, Colin Hyde and Bill Barnes from Flamethrowers and Fuels; and Charlie Hubley, Art Grey, Cathie Scissons, Ray Gravelle, Yvon Marois, Marcus Weinberger, Tom Mousseau, and Pat Lutley from General Chemistry.

If anyone's name has been left off, I can only apologize.

PROTECTION FROM THE ENVIRONMENT - 1960-1977

by

Harry Nash and Rita Crow

"D" WING - 1960-1969 - by Harry Nash

In contrast to other DRB Establishments, DRCL had a considerable industrial manufacturing capability, originating in its wartime pilot-plant facility, and performed much development work. In the late '50s, DRCL's Sections were reorganized into "Wings" and those Sections relating primarily to development (as opposed to research) were grouped together into D Wing.

The Wing initially consisted of a Chemistry Laboratory and a Chemical Testing Laboratory (Proofing Lab) (both under Lloyd McDermot), a Physics Laboratory (Lloyd Wilson), a Physiology Group (Arthur Custance), a Rubber and Plastics Laboratory (Harry Nash), Engineering Facilities, including Prototype Design and Pattern Shop (Dave Norman), Physical Testing Laboratory (Lloyd Wilson), and a Chemical Engineering Pilot Plant (Jim Wheat).

The main objective of the Wing was to develop individual protection for the military serviceman against the environments to which he may be subjected - chemical, biological and natural environments being the principal subjects of research and development. The Wing also had the facilities within the Engineering Group, the Rubber and Plastics Laboratory and the Pilot Plant, to fabricate prototypes for testing and evaluation, and development of the expertise needed to transfer development to Industry.

The design of the protective mask and its components for chemical and biological defence has been one of the longest-standing projects. The performance of the Canadian Forces gas mask had been improved significantly in its protection against chemical and biological warfare agents and nuclear dust. Improvements were due to continued improvement of materials for the facepiece, both for extending shelf-life and for non-dermatitic characteristics; improvements in speech transmission; and in canister design. For the canister, a vastly-superior filter paper was developed by the Pilot Plant. Other items developed at DRCL now in use by the Canadian Forces are impermeable gloves and boots and a permeable Chemical Warfare protective garment. Spectacles designed to be compatible with the gas mask and to remain in position during violent activity have also been developed.

For decontamination of chemical agents from skin, a mitt containing powder which removes chemical agents from human skin, clothing, and equipment had been devised. D Wing also participated in the development of chemical agent detector paper and the nerve agent vapour detector and led the transfer of manufacture of these items to Industry.

In the course of his duties, a serviceman is exposed to a range of natural environments, extremes of cold, heat, and humidity as well as rain and snow. Applied research has been directed towards materials development and fabric design for clothing and towards improving the materials through improvements to properties such as oil and water repellency and flame retardancy. Studies relating to cold-weather clothing for the far north and the arctic led to development of a nylon-pile synthetic fur, now ubiquitous in the civilian fashion world. The nuclear threat also lead to the development of Nimbus Cloth - a treated mesh fabric for the protection of the individual against the radiant-heat flash produced by a nuclear weapon.

Because of its facilities and expertise, DRCL has been asked to assist in problems and requirements from other Defence Establishments both R&D and military (for example; developments of battery cases for Search and Rescue transponders, special rubbers for gasoline handling equipment) and other Government Departments. An example is the development of bank note paper for the Bank of Canada.

To assist in the development work a Military Test Team had been assigned to the Division so that trials of various experimental-design items could be carried out at the Establishment under both controlled- and outdoor-conditions. This team also participated in cold weather testing trials at Ft. Churchill, Man. (This team remains with DREO to this day, participating in tests of environmental- and NBC-defence clothing systems.)

In 1970, "D" Wing, along with "A" and "B&C" wings were merged to form the NBC Defence Division. "D" Wing's Chemistry, Chemical Proofing Labs, and Rubber and Plastics Groups or Sections were amalgamated with "B&C" wings Chemical Defence Section into a new Chemical Defence Section. The Physics Section, the Physical Testing Lab, the Seamstress, the Physiology Section and the Military Test Team were also amalgamated to form the new Physics and Test Section. A new Engineering Section was formed from the old Engineering Section, the Machine Shop, the Model Shop, and the Drafting and Illustrations Group. The Pilot Plant took over some of the functions of the old Chemistry Section. In 1972, an Exploratory Studies Group was added. Its primary concerns were with problems of operations in the arctic, and with arctic clothing. Most of the cold-weather clothing work and most of the physiology studies were transferred to the new group, along with staff from the Physics and Test Section, and from the old Chemistry Section, and also the Military Test Team. In 1973, this group evolved into the Environmental Protection Section. The story of this new section is taken up by Rita Crow in the following pages.

The people of D Wing, and the Sections or Groups in which they were employed are shown below.

"D" Wing Staff

Wing Superintendent - Wib Cowie

Chemistry

Lloyd McDermot
Rex Richards
John Hart
Rolly Fuoco
Marg Glassford
Olga Ericson

Seamstress

Jeannette Whelan

Physics

Lloyd Wilson
Gaston Drew
Pat Cavanaugh
Malcolm Dewar

Chemical Proofing Lab

Geo Paquette
Chris Wellington
Oliver Sturk

Physical Testing Lab

Margaret Riches
Rick Nolan
Patrick Dolan

Pilot Plant

Jim Wheat
Don MacLeod
Bob Dunlop
Chuck Thompson
Doug Scharf
Joe Doherty

Rubber and Plastics

Harry Nash
John Collyer
John Montgomery
John Clark

Engineering

Wib Cowie
Adrian Ruddell
Dave Bulleid
Al Locke
Dave Norman

Drafting and Illustrations

Ron Davis
Lorry Corrish
Rosemary Maxwell
Judy Hardin

Model Shop

Ken Young
Ray Mitchell
Garnet Studholme
Rolly Arbique

Respirator Assembly Plant (terminated, 1965)

Tommy King
Bill Taylor and casual staff

Physiology

Arthur Custance
Stan Cattroll
Mace Coffey
Blake Nash
Phil Sargeant

Machine Shop

Bill Dickson
Vance Nyman
Mike Brouse
Alan Hollingsworth
George Kennedy
Ab Hewitt

The Military Test Team

Officers, NCOs, and other ranks, over the years were:

- Maj. J.B. Nash, Sgt. G.E. Griffin and 10 other ranks*
- Capt. T.E. Flynn, Sgt. G.E. Griffin and 10 other ranks
- Capt. A.F. Cameron, Sgt. A. MacKenzie and 10 other ranks
- Capt. A.F. Cameron, Sgt. P. Mann and 10 other ranks
- Capt. A.J. Cooke, Sgt. P. Mann and 8 other ranks
- Sgt. P. Mann and 8 other ranks

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* A posting to the Test Team for other ranks was for one year only, and, annually, they were replaced.

THE EXPLORATORY STUDIES GROUP AND THE ENVIRONMENTAL PROTECTION SECTION -1969-1977

- by Rita Crow

The Environmental Protection Section came into being in the early '70s for political and practical reasons. John Diefenbaker's election campaign had, as one plank, "a true north strong and free". Of course, he and his party were successful and had to take action to implement the premises of this slogan. A second political consideration arose from the new oil-exploration activities which had begun in the North -- and there was widespread fear that an environmental disaster might occur. The 1971 White Paper on Defence states that "The Forces, with the help of the Defence Research Board, have been in the forefront of the opening of the North and have pioneered in finding solutions to the problems of development. This role will be enhanced in the future."

This role had grown out of earlier work which stretched back to the early '50s. However, in 1968, an in-depth review recommended that the research effort in NBC be cut back, which would have a major impact on the Personal-Protection Program. In order to preserve the expertise which had been built up in protective-equipment design and in physiological evaluation, a new program of applied research not so closely associated with Chemical Defence, but with major emphasis on the Arctic was proposed.

Wib Cowie, former Superintendent of the Developmental Wing, was charged with formulating this new research program. His first step was formation of "the Exploratory Group" in 1971. Several new graduates were hired for it. In 1972, this Group was amalgamated with the Physics and Test Section to form the Environmental Protection Section. The Physics and Test Section included a Physics Group (Lloyd Wilson), a Testing Group (Rick Nolan), Human Engineering Group (Douglas Soper) and the Army Test Team (Harry Nash).

The first few years were spent in developing various expertise areas of the new staff, and formulating a research program. Personnel went on military winter exercises to experience, at first hand, existing CF clothing, equipment, and procedures; and to identify deficiencies in these areas. Early work included the "mobile shelter" (an RV with tracks) in conjunction with DCIEM and a clothing survey for the Arctic Petroleum Operators Association. Also, a detailed bibliography on arctic clothing was written.

The first aims of the Section were to study materials for use in protective clothing and shelters and to achieve integration of systems of clothing, shelter, and transport. (These aims remain current today.) Insect repellency, static-electricity problems, and physiological evaluations of clothing and equipment were also taken on by the Section.

By 1973, the formalized tasks of the Section included work to combat static electricity on clothing, to measure heat energy transmission through fabrics, to evaluate improvements to clothing, to improve heating and lighting equipment for the Arctic, to solve the frosting problem of eyewear, to develop militarily suitable facemasks, to develop electrically heated hand and footwear, and to overcome the problem of moisture accumulation in sleeping bags. More staff was added that year and the never-to-be-forgotten-by-the-participants 5-day Exercise Gatineau, was undertaken to familiarize all Section personnel with the myriad of problems which can arise when operating in a cold environment.

In 1975, Lloyd Wilson retired and John McAndless became the Section Head.

In the next few years, tasks were added for development of improved rainwear, for evaluation of heat-stress protocols, studies of manual dexterity of CW gloves, improvements to arctic footwear, studies of the parameters of heating the CF 10-man tent, and studies of heating and power generating. Each year at least one member of the Section went on some type of winter military exercise.

Close cooperation with other nations with interests in the arctic was set up and joint R&D programs were undertaken. The relationship with Norway was particularly close because of Canada's commitment of a Brigade to the Northern Front, to be deployed in Norway. Tor Oftedal of the Norwegian Defence Research Establishment came to the Section for one year as a visiting fellow and worked on tent heating systems. Another Norwegian, Bjarne Nordli also came for one year a few years later to work on load carriage, including a backpack/toboggan concept.

An account of the more recent activities of the Protective Sciences Section is presented by Charlie Clifford in the following section.

THE PROTECTIVE SCIENCES DIVISION

by

Charlie Clifford

INTRODUCTION

The "NBC" Defence Division was renamed the "Protective Sciences Division" in 1977. This name more accurately reflected the responsibilities of the six Sections of the Division to the aim of protection of CF personnel from the effects of chemical agents and nuclear fallout, from radiation effects, and from adverse environments. Over the next decade, major changes were made to the make-up and resources of the Division and to the nature of its particular responsibilities. These changes arose from two major decisions of senior CRAD management that were taken early in this period, and from a requirement to address new concerns in personal protection. The management decisions were, firstly, to make DREO the lead establishment for defence research on electronic warfare, radar, and surveillance (i.e. to make DREO into a reborn and revitalized DRTE), and secondly, to consolidate the divided DREO/DRES chemical defence research programs into a refurbished DRES. This would require an associated move of the small Environmental Protection Program and the supporting CF Test Team from DREO to either DCIEM or DRES. The new concerns in protection came from the growing realization that the focus of future research should be less on providing increased levels of protection to chemical agents, harsh natural environments, and shielding of personnel against nuclear radiations -- which were the main aims of the division -- and more on improved performance of the protected personnel. This also would entail addressing the nuclear and chemical hardening of the equipments to be used by the protected personnel, to ensure the balance required for operational survivability. The three areas for protection noted above derived from the defence research programs that had made up the original DREO.

Because of the future role as a primarily electronics-oriented Establishment that was being implemented for DREO and major cutbacks in its original role, the staff of the Protective Sciences Division (PSD) faced considerable impending disruptions. These included staff reductions and relocations, and decreased priority of their programs for capital funding. PSD had the advantage, however, of mature, productive programs in exciting areas of defence research and the military's stated urgent requirements for much of their work ensured that the laboratory facilities and programs would continue to be maintained until they could be placed elsewhere. In addition, international commitments required that collaborative programs with ABCA and NATO Allies would be maintained. This was accomplished through the TTCP subgroups and NATO panels. The high level of professionalism of the PSD staff throughout the period of change from 1977 to 1988 was reflected in their continued high productivity. With less than 30% of the professional and technical staff of DREO, and with capital allocations for programs of about one-sixth of that available to DREO as a whole, PSD staff produced about one-half of the total of scientific papers, reports and technical publications of DREO!

CHANGES IN PSD STRUCTURES

Major changes to the organization of PSD included the integration of the Radiobiology Section (RBS) into the Nuclear Effects Section (NES) in 1982, the transfer of NES from PSD to the Electronics Division in 1988, the renaming of the Chemical Defence Section as the Chemical Detection and Decontamination Section (CDDS) in 1986, prior to the relocation of these responsibilities (together with the CDDS staff positions) to DRES in 1987/88, and the combining of the Engineering Section with the Materials Section to form a new

Chemical Protection Section (CPS) in 1985/86. The Environmental Protection Section (EPS) continued largely unchanged.

The following sections summarize the developments and accomplishments in each of the three program areas of PSD: Nuclear Effects, Chemical Defence, and Environment Protection.

NUCLEAR EFFECTS

Radiation Transport Studies

By the late seventies, considerable progress had been made in the areas of radiation transport and dosimetry. The radiation-transport work had been directed to evaluation of the radiation dose that would be received by a person exposed to gamma rays associated with nuclear weapons or to the fallout from nuclear weapons, under a range of shielded, semi-exposed, and full-exposure conditions. Much had been learned about the relationships between the radiation exposure that could be recorded by a dosimeter worn on the body or indicated by the reading on a radiation monitor, and the actual absorbed dose, and the consequential biological effects produced in the critical areas of the gut and the bone marrow system of an exposed person. Knowledge of these relationships provided the basic information which allowed us to advise the CF on survival probabilities and on the related question of radiation-shielding requirements for personnel that could be exposed to gamma radiations on the nuclear battlefield, to increase survival probabilities.

While the gamma-ray transport studies had made considerable progress, major problems still existed with the knowledge gap in exposure to the fast neutrons that are produced by tactical nuclear weapons. In particular, there were considerable uncertainties in predictions of the radiation dose that would be received by personnel who otherwise could be expected to survive the heat and blast of a nuclear weapon because of being shielded physically by an armoured vehicle or a field bunker. To address this problem, Frank Szabo, Alan Robitaille, Tom Cousins, and Bernie Hoffarth built a unique, self-contained, state-of-the-art fast-neutron/ gamma spectrometer that was field mobile. This was used to measure the dose received at various locations within a battle tank exposed to neutrons from a high-energy neutron generator. This neutron generator had been earlier established as a field facility at DREO by Frank Strain. The results of this unique work were presented to NATO in 1981. These led to an intense International collaborative effort -- particularly with the USA, France, UK and West Germany (FRG). The goal was to develop computational models for weapons' radiation transport that could be evaluated against field measurements. The US was so impressed with the Canadian work (and the spectrometer) that an MOU was signed (CDA/USA) that provided the DREO researchers with use of the American's major nuclear-weapons field simulator at Aberdeen Proving Ground (APG). The mobile spectrometer was used by Frank Szabo and his colleagues in a series of field trials starting in 1983 at APG to determine the shielding provided by armoured vehicles. Ross Hirning conducted measurements at these trials of the doses received at critical regions of the body using the DREO human phantoms. DREO also was invited to participate at a trial at Los Alamos in 1983 using the DREO spectrometer to measure the radiation profile of a sub-critical nuclear weapon. The collaborative studies that were initiated through NATO, the MOU with the US, and through the Franco-Canadian Accord, as a follow-on to the spectrometer development at DREO, helped to put the Canadian scientists at the forefront of international radiation transport studies.

Non-ionizing Radiations

From 1975 until its completion in 1982, a study was conducted to determine the safe levels for exposure of humans to non-ionizing radiations (i.e. microwaves) by Alan Cairnie, Doug Hill and Karen Leach of the Radiation Biology Section (RBS). The study was conducted as a joint project with NRC. The experiments required the construction of a very large electromagnetic irradiator, followed by studies with animals, human phantoms, and ultimately, human volunteers. The subject was of considerable international interest and the DREO/NRC results were presented at a special NATO Symposium in 1983. The levels of exposure established by the DREO/NRC studies subsequently were incorporated into the Health and Welfare Canada* Standards for exposure levels vs. frequency for microwave radiation.

Radiation Induced Nausea

Upon completion of the microwave studies in 1983, this joint DREO/NRC project was terminated. Alan Cairnie and Doug Hill transferred from the RBS to other DND programs, and the remainder of the RBS staff were relocated from their laboratories in the Biological Sciences Bldg at NRC to similar facilities at the University of Ottawa, provided on contract. This contract not only provided laboratories and services for the DREO staff, but also provided some professional support and allowed the relatively small DREO program to operate in the broader professional environment of the U of O Physiology Dept. At this new location they continued the studies on the protection of the individual from the biological effects of exposure to nuclear radiations. The studies of Bill Ross concentrated on materials that appeared promising for radioprotection at the cellular level and the work of Kent Harding involved seeking out the causes of radiation-induced nausea. A singular success was achieved in this latter area in the late eighties. In a series of experiments, first with rats and finally with dogs, Kent Harding identified the particular area of the brain (area postrema) that was responsible for the nausea produced by radiation exposures. This knowledge was the essential first step toward development of a targeted drug that could ensure the continued high performance of CF personnel exposed to usually non-lethal doses of radiation that normally incapacitate by causing severe nausea. This work also has implications for alleviating the nausea experienced by cancer patients from radiation therapy.

Radiacs and Dosimeters

The earlier work of NES on the development of radiation measuring instruments (radiacs) and combined neutron/gamma personal dosimeters was largely completed during the eighties. Phil East developed a compact, light-weight, wide-range survey meter and Sid McGowan developed a unique solid-state dosimeter based on use of a MOSFET detector. Throughout the period from 1977 to 1988, close contact was maintained with the CF requirements and engineering Directorates at NDHQ to ensure that DND's requirements for either radiacs or dosimeters would be met by state-of-the-art equipments. The CF was unable to adopt new equipments in this time frame (funding was lacking), however, DREO technical support continued to be supplied to the Forces by Dave Benyon, who recalibrated and maintained the existing obsolete CF equipments until his retirement.

Equipment Survivability

The shielding studies on protection of personnel, and the concurrent studies in radiobiology to ensure that personnel exposed to high doses of radiation will remain combat effective, raised the question of the survivability of equipments also exposed to nuclear radiations. The known effects on equipments could be either direct damage to sensitive components i.e. Transient Radiation Effects on Electronics (TREE), or indirect damage to electronic systems triggered by the Electro-Magnetic Pulse (EMP) associated with nuclear detonations. These effects can occur at radiation exposure levels where the operator could survive. EMP has been widely studies by other countries. It usually requires the construction of a large test facility to assess procedures to shield whole systems from EMP. In the late '80s, DREO undertook the development of such a full-size EMP facility. While these studies were to be carried out by NES, this Section was transferred to the Electronics Division. The similar TREE program, started by NES in the mid-'80s while part of PSD, included studies on the direct effects of nuclear radiations on various sensitive electronic components. This was a significant extension of the NES expertise in radiation transport studies, and by the late-'80s, Gary Pepper, Tom Cousins and Frank Szabo had developed procedures to use the existing DREO irradiation facilities in studies of direct damage. With the transfer of the NES to the Electronics Division in 1988, the studies on TREE and EMP were consolidated.

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* The federal agency responsible for setting safety standards for exposure to non-ionizing radiation.

CHEMICAL DEFENCE

Decontamination

An ongoing problem in chemical defence has been to achieve effective decontamination of a contaminated surface. It must be timely, within a few minutes, and virtually complete, if it is to help the soldier and to prevent casualties. Since most materials that can decompose a chemical agent rapidly and completely are extremely caustic, or are dangerous themselves, there has been concern both for decontamination of human skin (or sensitive equipments) as well as for vehicles and other surfaces. In 1974, DREO began a search for new approaches to skin decontamination that would overcome corrosivity problems. A team led by Bob Bannard with assistance from Al Casselman and Gail Thompson soon focussed in on macrocyclic ethers and their unique abilities to form highly reactive complexes with inorganic salts in non-aqueous solvents. The properties of many of these complexes included the abilities of accomplishing rapid and complete destruction of liquid CW agents. The mechanisms of these complex-formation and agent-destruction reactions were not known and these aspects were studied by Garfield Purdon at DREO and Erwin Bunsell at Queen's University on contract. These studies showed that high nucleophilic activity was not necessarily accompanied by the high basicity or oxidative properties which characterize high corrosivity on skin, and that "benign" decontamination might be feasible. Toxicities of several of the most promising crown ether-nucleophile complexes were studied, and found to be low enough that their use in skin-decontaminant formulations would not be precluded. When tested against animals, these systems provided complete protection against liquid GD, and one formulation tested also accomplished complete destruction of liquid mustard in a vehicle-decontamination trial.

The system however required very large quantities of the very expensive crown ethers, and simpler, more affordable systems were sought. These were found in the relatively-cheap mixed polyethylene glycol methyl ethers as substitutes for the crown ether component and several highly effective decontaminant systems were developed.

From the encouraging results achieved, the project was expanded, and DREO went on to develop "barrier creams" which could be applied before exposure to liquid agents and would render CW agents ineffective on contact. Garfield Purdon and Ted Dunn, with the support of John Bovenkamp, investigated a series of materials to develop a "Reactive Skin Decontaminant" (RSD), a much less grease-like material, with a consistency much closer to motor oil. These were designed to be applied after contamination of skin by liquid agent and, similarly, to decontaminate the agent on contact. The project was successful and candidate skin formulations were tested at DRES to allow their acceptance for service use by the Surgeon General. This work resulted in a fieldable benign lotion for the CF. Its development was accelerated so that it was available to the troops in the Persian Gulf during the very recent Gulf war. As a follow-on to the RSD lotion, a similar low-viscosity formulation was developed as a potential non-damaging decontaminant for vehicles. The Chemical Detection and Decontamination Section was closed at DREO in 1988, however, this work continues at DRES under Garfield Purdon.

Detection

Two important detection technologies were highlighted at DREO in the '80s One was an old technology that had an unexpected urgent revival and the other was an application of state-of-the-art ion-mobility studies. The first involved the 3-way chemical agent detector paper which had been developed in the early sixties. It was a low-cost, effective way to identify and classify liquid chemical agents. The technology had been transferred from DREO to a Canadian manufacturer and it had continued to be sold widely to most of the NATO countries, and to many other friendly Nations, to 27 countries in all. Unfortunately it was discovered in the early '80s that its production involved processing of two mutagenic dyes which could prevent the paper's continued manufacture in Canada unless special facilities were provided. Since a three-dyestuff system was essential to identification of agents, a project to develop non-mutagenic substitute dyestuffs was undertaken by John Bovenkamp, with the support of Jim Wheat, Kim Dix, and Bennie Lacroix. At first this was an in-house project. Later, a contract with Anachemia was let that provided two scientists to work full time at DREO to take advantage of DREO's dyestuff-processing, paper-making, and CW agent-handling expertise. This project was fully successful and a new 3-way detector paper, indistinguishable from the old by the soldier in the field, has been developed and this item remains a standard equipment for chemical defence, and also has preserved our foreign markets.

The second detector highlight was the innovative application of ion-mobility technologies to the detection and identification of minute quantities of chemical agent vapours. Jon Preston of DREO had been involved in some of the early fundamental studies of ion mobility in collaboration with Dr. Karasek of the University of Waterloo. Later, with the support of Larry Hart, he was a major contributor to studies of the practical application of ion mobilities to CW agent detection. This became an intensive collaborative effort among Canada, the US, the UK and Australia though TTCP Subgroup E on Chemical Defence. The close collaboration between the TTCP scientists culminated in the successful development of a small self-contained, hand-held detector for chemical agents. A commercial device based on this development was manufactured in the UK as the CAM (Chemical Agent Monitor) to detect liquid agent contamination on surfaces. It was acquired by the CF.

The CAM served as the basis for development of an automated detector and alarm for CW agent vapours. Previous work started by Jim Norman in the late '60s and extended by John Hart had developed a prototype Liquid Agent Detector and Alarm (LADA) system. This had been further refined by Jon Preston and Larry Hart in the '80s. To complement this liquid agent alarm system, Jon Preston developed an agent-vapour alarm system that incorporated the CAM as its sensing agent and then added much signal processing capacity to allow functioning as an automatic alarm. The device was first called CAM/CADA (Chemical Agent Monitor/Chemical Agent Detector and Alarm) and later renamed CAVA (Chemical Agent Vapour Alarm). With the closing of CDDS in 1987/88, Jon Preston transferred to DREP, to another program area, however, Thor Jacobson and Larry Hart moved to DRES in 1988 to continue work on automated chemical agent detection.

The C4 and AC4 Masks

In the mid-'70s, both Canada and the USA had recognized the urgent need to replace their stocks of masks which, at that time, were at the limits of service life. Those in-service masks had operational deficiencies that could not be overcome by minor design or materials changes. The opportunity to mount a collaborative new-mask program through an MOU with the USA was seized. Canada undertook the development of the canister while the USA undertook the development of a new facepiece, these two pieces then would combine into a new, improved, common mask for both Canadian and US Forces. By the early '80s, DREO had completed a successful new-canister development. Industry had been involved and this canister was in production as the C2 canister. The first US facepiece development had turned out to be non-manufacturable, being beyond the current manufacturing state-of-the-art. Canada was faced with replacing its current obsolete masks with more of the same (but incorporating whatever new materials or design technologies which had been developed). A Canadian backup design program for a new facepiece was started in case the USA program should continue to be delayed and a development project was undertaken at DREO, starting in the late '70s. It was very confused at first with conflicting responsibilities (CRAD HQ, DG/EM, DREO), lack of funding, inability to tap into appropriate modern technologies, and with divided project management, but after a few years it was taken over by Brian Harrison. Andy Main was taken on as Project Manager and provided the necessary drive. A totally new facepiece, the XC4, was developed on time and within budget to meet fully all the Forces stated needs. The USA program continued to lag and the new Canadian facepiece and C2 canister were accepted by the CF in 1988 as the C4 mask. Among its many features were: greatly improved vision, much greater comfort for extended wear periods, greater agent resistance, a water-drinking capability, improved speech transmission, and lower manufacturing cost than the mask it replaced. Among the many DREO participants in this project were John Collyer and John Clarke who developed new agent-resistant material for the facepiece; Pierre Meunier who used the computer-aided design (CAD) system to develop many of the new design innovations; Dave Hidson who specialized in the voice transmission aspects; Larry Constantine who carried out the physical tests; the DREO Test Team under Rick Nolan who evaluated the comfort, wearability and performance of the various development models; and other staff of the CPS and CDSS who assisted with agent tests of the facepiece components. This intensive 3-year project made extensive use of Industrial Contracts both to support the mask development and to ensure that the appropriate technologies would be in place in Industry when the C4 went into production.

As a spin-off to the C4 development, Pierre Meunier and Kim Dix developed an aircrew version of this mask, the AC-4. This version included the addition of a hood to conform to aircrew helmet requirements and changes to the ventilating system to permit the use of forced air. The result was a mask that not only exceeded the capabilities of the aircrew mask currently in use by the CF (a UK-designed full-head mask) but was less costly, less than one-tenth of the cost of that UK mask.

New CW Protective Clothing Systems

The 1980's view of protective clothing was that the current chemical protective ensemble consisting of the NBC mask and various clothing systems: a CW coverall, CW gloves and CW overboots; provided adequate protection for all credible CW agent exposure conditions on a battlefield (except for direct hits). Attention therefore was directed to alleviating the very severe operational-performance constraints imposed by this system, primarily the heat load and wearability factors. The development of the C4 mask was an excellent contribution to an improved system. Another area of focus was the chemical protective glove. A model brought out in the '70s was heavy and cumbersome but did provide good protection. In the early '80s, John Collyer and John Clarke developed a highly-resistant latex-based dipping formulation which permitted redesign of a general-purpose glove to overcome most drawbacks and also allowed the development of a light-weight glove. One use for this glove was by aircrew where greater manual dexterity was essential, a second was as a CW-resistant surgeons glove for use by medical staff in the field. All impermeable gloves are plagued by problems of sweat-build-up. Experiments were undertaken by Sylvie Boissé using the Test Team to evaluate candidate glove liners that could reduce these sweat buildup problems. By 1988, a much improved glove had been developed but much remained to be done to find better hand protection.

The chemical-protective one-piece overgarment that had been developed for the CF in the '70s was based on a "permeable-garment" concept and used a charcoal-impregnated foam sandwiched into layered permeable materials that absorbed chemical agents but which allowed some cooling-air circulation and which reduced the sweat buildup markedly from that produced with an impermeable garment. In its time, it was the best overgarment available worldwide. It continued to remain better than those of most other Nations since it could be laundered and reused many times, without losing its effectiveness. Like all comparable overgarments, it could produce a considerable heat load during field operations and it was bulky. The work of John Hart at DREO in the '60s and on into the '70s on charcoal loading of foam materials had provided a good technology base in this area and this was pursued in the '70s and '80s by Kim Dix, to explore charcoal loading of other light fabrics or similar materials that might provide an alternative to the charcoal-loaded foam layer of the overgarment. Success was achieved with certain stretch materials.

Concurrently, studies by Brian Farnworth of EPS, on the heat load of multilayered clothing systems and on heat dissipation suggested that significant heat-load reductions would be achieved by replacing the current loose-fitting protective outergarment by a near-skin-tight protective layer. Initial experiments by Syd Livingstone and Rick Nolan using the Test Team supported this concept and in 1988 a joint study was launched. DCIEM and DREO's CPS and EPS were the collaborating entities. This work emphasized the compromises that must be made between agent protection on the one hand and ability to carry out military operations on the other. There now appears to be a shift in emphasis in clothing systems away from near-100% protection to those that allow better military performance, indicating major changes to both materials and design of future clothing systems.

An essential part of a chemical protective system is the assurance that it will continue to work against any credible hazards. The Canadian system was designed to protect against the chemical agents (in either droplet or vapour form) that were known in the early '80s. It was necessary to continue a watching brief on performance of the system against newly-discovered toxic materials to ensure that the chemical protective clothing and mask, canister system developed by DREO would in fact continue to protect against any potential new agents that might be fielded.

Upgrading of Chemical Testing and of the Chemical Test Laboratory

One of the earliest mandates of DREO, going back to 1938, involved the operation of a test facility to carry out "proof testing" of the products of the RAP, and later, of all material manufactured for Chemical Warfare use. While the scope of these activities was greatly reduced after WWII, they never ceased completely, and they remained a responsibility of Development Division's Chemical Test Laboratory located in Bldg 6. With the formation of the NBC Defence Division, Development Division's Chemistry Section and the Chemical Warfare Section were merged, to form the Chemical Defence Section, and the Chemical Test Laboratory became the responsibility of the new section. Its function continued, to proof gas masks, canisters, CW protective clothing, boots, gloves, etc. and to support R&D activities by carrying out the standard proofing tests on new materials -- for example, new respiratory charcoals, new fabrics, new rubber formulations -- developed by the Chemical Defence Program.

Most of the equipment and analytical procedures dated back to wartime days and were slow, labour-intensive, and, often, relied on the abilities of long-time employees to recognize a particular end point. The start of serious attempts to modernize the methods and equipment in use in the Test Laboratory was begun by Bob Bannard in 1970. This program was continued and extended by Garfield Purdon through the mid-'70s, and completed by Brian Harrison by about 1983. In 1986, the Test Laboratory moved from its original location in Bldg 6 to join the other laboratories of the Chemical Defence Program in Bldg 5B. This has resulted in very close collaboration on, and standardization of testing methods, analytical procedures, and test equipment between "Proof Testing" and "R&D Testing" activities. In this way, the most modern computer-controlled equipment and methodologies; for example, GC, GC-MS, UV-VIS-IR Spectrophotometry, and a host of other precise analytical technologies, is now available and in routine use in the Proofing Laboratory.

The evolution of CW Protective Clothing with heavy loading of activated carbon and its resultant extremely high capacity for CW agents created special problems in evaluation, and design of suitable test equipment became a special task. This had international implications and this task soon became a cooperative collaborative R&D project by Canada, USA, Britain, and Australia and became an action group, AG12, under TTCP Subgroup E. Each nation submitted a design prototype (and appropriate methodology for use) and then an "Evaluation Workshop" was conducted at DREO. The DREO design and analytical method, to which Neville Gibson, Ron Davis, and Brian Harrison had made major contributions, won out and was selected as the standard* by the four participating nations.

At the same time as the chemical test method was being developed for CW protective clothing, a method utilizing a biological test was being developed in parallel, by Ann Finkbeiner and Regina Sheppard. In this, clothing penetration by nerve agents was being correlated with blood cholinesterase levels including gross depression and those associated with red-cell and serum cholinesterases separately. As this work was nearing completion, a decision was made by senior management to terminate all animal testing at DREO and shift the work and the personnel involved to DRES. Unfortunately, this did not work out. The personnel transfer was not possible: Regina Sheppard was killed soon after in a traffic accident, and Ann Finkbeiner had other responsibilities which prevented her from leaving the Ottawa area, so the work was not taken up at DRES; instead, it was allowed to die.

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* In the early eighties, this standard apparatus, with slight modifications, was found suitable for the rapid evaluation of candidate Barrier Creams as protectants against liquid CW agents.

ENVIRONMENTAL PROTECTION

From 1977 to 1988 the primary aim of the EPS continued to be to provide the land element of the CF with effective protection from the natural environment, particularly for Arctic conditions. This was accomplished by response to a broad range of specific equipment-oriented tasks, mainly from DCGEM. Studies were undertaken at DREO to identify parameters important to Arctic clothing and shelter systems. These included the transport of heat and moisture through materials and the physical properties of candidate materials for prototype clothing and equipments. The Section made extensive use of the CF/DREO Test Team for evaluation studies. These were carried out in the laboratory or in the DREO Environmental Chamber (which was completely rebuilt in 1986) and a series of local trials at the DREO Wear & Design Course or in the more remote reaches of Gatineau Park. An important element of EPS operations was the winter field trials of experimental and prototype clothing of heating systems, of tentage and of other equipments carried out annually in the North. Twelve exercises were carried out by EPS staff in the Canadian North between 1977 and 1988. These included a series of winter exercises along the western shore of James Bay that was initiated by Randall Osczevski. The winter exercises provided invaluable direct knowledge of protection requirements and the performance of candidate equipments under realistic, harsh, Arctic military conditions.

EPS expertise in the properties of clothing materials, human thermoregulation, and the heat loads posed by possible clothing systems was utilized in the late '80s to support CPS studies on future chemical protective clothing. In 1988, this work was extended further to a broader study on a future Integrated Protective Clothing (IPC) system.

The following items describe some of the highlights of EPS activities in the 1977 - 1988 period.

Water Vapour Transmission

This is an important factor for any candidate material for clothing systems. The test for this property was developed by Brian Farnworth in the late '70s. It since has been adopted as the Canadian Standard. Brian Farnworth also developed an apparatus -- described as a "sweating hot plate" -- to investigate the water-vapour-transmission properties of a given material next to the skin. This device gave realistic and reproducible results and proved to be a valuable tool to compare candidate clothing materials.

Sleeping Pads

One serious defect in sleeping bags has been that the weight of the occupant compresses the underside of the bag. This reduces the insulating properties of the lower layer and, in the Arctic, permits large heat losses to the frozen ground. A conventional insulating mattress which must be carried by the man creates operational problems of bulk, weight, etc. In the mid-'80s, Brian Farnworth and Randall Osczevski developed a novel sleeping bag that replaced the conventional underside of the bag with an ingenious built-in insulating pad. This pad was rigid in the vertical direction when spread out for sleeping but could be compressed in the horizontal and thus easily carried when the bag was packed for transport. Prototypes of these sleeping bags were evaluated in Arctic trials and proved to be highly successful.

Tentage

In the early '80s, Brad Cain developed a candidate multilayer, insulated material for tentage. It also incorporated a water-repellent layer for rainproofing but tests showed that there was a moisture-buildup problem on the interior tent wall. A wicking layer then was added to drain off this condensation. Tests at DREO indicated that it also could overcome the wide temperature variations seen in conventional tents in cold-weather operations. Prototype 3-person tents were constructed of this material and were evaluated by Brad Cain, Brian Farnworth and Randall Osczevski in Arctic trials. The results demonstrated that greater comfort for the tent occupants and a considerable reduction in fuel requirements for tent heating could be achieved, compared with current cold-weather tents.

Layered Clothing Systems

The conventional approach to cold-weather protection is the use of multiple-clothing layers. For the military with many different outdoor levels of activity required, the protection demands are adjusted by the addition or removal of clothing items. In practice, this is complicated by a requirement for removal and redonning of an outer wind and wet-proof-layer before adjustments to underlayers can be made. The experiments of Randall Osczevski in the late '70s showed that the complicated procedures (and the logistics burden) for adding clothing for periods of low physical activity could be alleviated greatly by the design of a new basic-clothing system. A system was designed by Farnworth, Osczevski and Cain during the '80s that could be either vented or closed as required to meet most activity levels. A single additional outer layer for extreme cold or periods of low activity could be donned. This system obviated need for the series of under layers for donning, and overcame logistic problems of current cold-weather clothing systems.

Other Items

During the late '70s, the Test Team and various other EPS staff assisted an entomologist, Ian Lindsay, in local field trials of candidate insect-repellent clothing.

Syd Livingstone's work on the influence of arteriovenous anostemoses (AVA's) on thermoregulation has shown that when blood flows through the AVA's, the blood returning up the arms does so preferentially via the superficial rather than the central vein. Thus when the extremities of a "cooled" human are warmed, the AVA's open and the warm blood goes directly to the body core rather than being cooled as it would be if it returned through the central vein. Also, when the extremities of a hyperthermic human are cooled, the cooled blood goes directly to the core. This method of warming or cooling allows over 100 watts to be gained or lost by the body.

During the '80s, Rita Crow completed studies on the effects of low temperatures on materials. She also studied the stress patterns in clothing from wear. The study also included determination of the parameters of different types of stitching and of seams. A major breakthrough in the understanding of water uptake in materials was made, this being a filling process, independent of fibre type.

A new understanding of the effect of cold discomfort and severe environmental conditions on the behaviour of troops in clothing trials led to the development of a new trial concept, Trial Run, to overcome the limitations. The Trial Run series required the development of a system for travelling distances on the order of 1000 kilometres, without support, in the northern winter.

THE SPECIAL STUDY ON "YELLOW RAIN", 1982-1984

by

Jim Norman and Garfield Purdon

In late 1977, rumours first surfaced of use of CW Agents against civilians in Laos and Kampuchea,* in particular, against the H'mong populations in these two countries. The reports of attacks were of liquids dispersed from aircraft and falling like rain, the initial dispersal-cloud being seen as silver, red, green, or yellow coloured, this last being the most frequent so that, in time, all such attacks came to be referred to as "Yellow Rain". The reports were puzzling in another way -- symptomologies reported did not correspond to those from any known conventional CW Agent -- however, thousands of deaths had been reported. The whole matter was of concern to the World and to Canada. As reports persisted, Canada undertook several assessments, including: visits by Canadian Embassy personnel to the sites of alleged attacks; dispatch to the area of two separate special fact-finding missions of senior, scientifically-trained investigators from NRC and from the University of Saskatchewan; a medical team from DND's Surgeon-General's staff to carry out an epidemiology survey; and a team from Health and Welfare Canada (HWC) to collect blood and urine specimens from claimed CW-agent casualties.

The Surgeon General's team also collected many samples of leaves, of powder scrapings, of blood and urine samples, and a few tissue specimens from one alleged victim who died very suddenly and very unexpectedly. One other item collected was a small plastic bag, given to the team by villagers who claimed it to be part of a weapons system. Typically, the leaf samples and the plastic bag exhibited a discrete-drop spray pattern of yellow material, easily scraped off the underlying support, all being consistent with many descriptions of a "Yellow Rain" attack. These were returned to Canada, to DREO for scientific analysis, in March-April 1982.

Somewhat before this time, the US State Department announced in late 1981 that they had identified the poisonous materials involved in "Yellow Rain" attacks, and that these materials were trichothecene mycotoxins: a series of extremely toxic natural products produced by many members of the fusarium family of fungi, and responsible for many outbreaks of human and animal food poisoning around the world. The trichothecenes were identified as T2, HT2, DAS, and DON (this last also is known as vomitoxin because of its effects on the stomach), all well-recognized chemical entities in the scientific world.

While DREO had been asked to take custody of and to conduct the needed investigations on the samples returned to Canada, it had no expertise in mycotoxin analysis nor in trichothecene chemistry and its role had been envisaged as one of coordination, arranging for needed technical work from others. Expertise in mycotoxin analyses was readily available locally, in the laboratories of HWC and Agriculture Canada (AgCan) because of their involvement with the public-health and animal-health aspects of trichothecene contamination of food stocks, and DREO made arrangements through DND and External Affairs for the needed analytical work to be available from these two government departments.

As a first step, specimens of the yellow-spot material were tested at DREO for the presence of conventional vesicant and nerve-gas CW agents (or their chemically-very-close relatives or their known decomposition products). None were found even thought extremely-high-sensitivity test methods (in the nanogram range) were used. At DRES, tests showed the yellow-spot material to be biologically active, containing a very potent haemolytic material (a biological property of most trichothecenes) and also that Fusarium Fungi were absent. Preliminary tests at AgCan indicated the material to contain appreciable quantities of the two trichothecenes T-2 and HT-2. Later confirmatory analyses at HWC and AgCan could not confirm the two materials found to be these two mycotoxins.

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* Similar reports concerned agent use in Afghanistan but, since that nation was in the midst of a full-scale civil war, investigation by Canada was not possible.

Unfortunately, there was an outbreak of fusarium fungi on Ontario's wheat crop with an attendant major contamination problem from vomitoxin and almost all of the promised assistance from AgCan and HWC had to be terminated as these Agencies diverted their resources to cope with the analytical needs of the Public-Health aspects of this outbreak. This forced DREO to fall back on its own resources and to develop an in-house capability for mycotoxin analysis. DREO's GC/MS/DS instrument was suitable, in general, for this analytical task, however, a few equipment upgrades, and high-precision attachments and parts had to be substituted into the instrument to ensure a full capability for the analytical work required. In addition, material extraction and handling techniques had to be worked out and placed on a quantitative basis through use of "spiked" samples; and unequivocal identification algorithms had to be entered into the data-handling and identification software, then verified by use of reference-sample "knowns". This last was made easier by the acquisition of the US Food and Drug Adminstration's machine-readable GC/MS Mycotoxin Fragmentation Spectra Data Bank, and its conversion to a format which could be used by the DREO Instrument.

After this preliminary work, the leaf samples were analyzed. Most of these samples were found to be negative for mycotoxins or to exhibit only traces of these materials. In a second attempt at analysis, all specimens from each separate attack were pooled and concentrated, and the analyses were repeated. While some samples again were negative, some did show the presence of small quantities of trichothecenes. The levels (expressed as contamination on the leaf in ppm) were about the same as background contamination levels found worldwide on normal cereal crops. Agriculture Canada was able to confirm the presence of trichothecenes on these samples, obtaining values similar to those found by DREO.

The plastic-bag sample was analyzed at both DREO and AgCan, unfortunately, not simultaneously (the AgCan analytical instrument was out of service for some weeks). DREO found very high levels of HT-2 and T-2 associated with the bag's yellow material. Later, AgCan confirmed the presence of these trichothecenes but found somewhat reduced toxin levels -- probably associated with non-uniform drop distribution on samples cut from the bag.

Blood, urine, and tissue samples were analyzed for DREO by AgCan using extremely-high-sensitivity analytical methods. No mycotoxins were found in any of these samples, nor in the formalin solutions used to preserve the tissue specimens during their transmittal to Ottawa.

In a further investigation, scanning-electron-microscope photomicrographs of the yellow-spot material of leaf samples and of the yellow material on the plastic bag were made by DRES. On leaves, the yellow material was found to be almost exclusively pollen grains: on the plastic bag, the material was an amorphous powder which contained virtually no pollen.

From these studies, it was possible to conclude that there was some evidence (not conclusive) for chemical warfare. A biologically-active yellow material which was a powerful haemolytic was detected, and there was no evidence of a natural origin for this material. The yellow material was observed as easily-removed yellow spots and exhibited a typical liquid-droplet fallout pattern on vegetation, suspiciously like that expected from overhead dissemination of a liquid followed by the fall to earth of medium-sized drops. Analysis of the yellow material on vegetation showed traces or small amounts of trichothecene mycotoxins, levels that approximate those reported for background levels from other parts of the world, and it was not possible to assign a CW significance to the results -- that is, CW attacks could be neither confirmed nor denied. The body fluids and tissues from alleged casualties were analyzed, and were negative for trichothecenes. The plastic bag was found to contain high levels of mycotoxins which might validate its claimed role as part of a weapons system. Its authenticity could not be guaranteed and the analytical results relating to it cannot be used either to support or to refute the CW-agent hypothesis.

All in all, while there was a plethora of other evidence to support the charges of chemical warfare, this study -- in spite of consuming much time and effort -- could neither verify nor refute these charges.

THE ELECTRONICS PROGRAMS

DRTE AND CANADA'S LEAP INTO SPACE: THE EARLY CANADIAN-SATELLITE PROGRAM

by

LeRoy Nelms

While the Alouette satellites brought Canada into the space business, an area of obvious interest to DND, the program's resounding success also caused the demise, ultimately, of DRTE. To this day, the whole story of the space program and its impact on DRTE, DRB, and DND is not entirely clear. It is, however, worth tracing the beginnings and early history of DRTE's involvement in the space program, because much of DREO's modern electronics-related work (and its three Electronics Divisions) have roots in this program.

The roots of what was to become DRTE were in the ionospheric sounding activities carried on by the Canadian Armed Forces and NRC during WW II, and sounding of the ionosphere to understand better the relationship between that region of the exosphere and long distance radio communications was a major activity of the Radio Physics and later the Communications Laboratories. Dr. Eldon Warren, head of the section involved in the "bottomside" soundings also carried out a series of imaginative "oblique incidence" soundings, over circuits in Canada, and in the late 1950's across the Atlantic. There was a large international community also involved in ionospheric research, as HF propagation (via the ionosphere in this era before artificial satellites) was the main method of long distance communications, other than land lines or microwave relay. (Just to round out the picture, DRTE was also at the forefront of meteor burst communications research and of some aspects of VLF/LF communications.)

With this scientific background, it was natural that the launch of the Sputnik satellite by the USSR caused Dr. Warren to realize the implications for long distance HF communications of being able to sound the ionospheric from above (topside sounding) from a satellite. The origin of the idea is not clear: it appears to be been current in discussions in many places; within DRTE among Dr. Warren, Dr. C. Hines, Dr. Chapman, Dr. Paghis, and others, and at about the same time was being discussed by Dr. P.A. Forsyth, then at Saskatoon. However, it was Dr. Warren who picked up the concept and put forth the daring proposal that DRTE should build a topside-sounder satellite; not a simple sounder operating on one or two frequencies, but a swept-frequency topside sounder that duplicated in a satellite the sounders then used in ionospheric sounding stations on the ground.

Conditions were right for such a proposal. DRTE had a first-rate Electronics Laboratory that had proven its capabilities in the "Velvet Glove" project and development of data-processing equipment for the Mid-Canada Radar Line, and had a considerable team working on transistors and other electronic devices. Young EL scientists and engineers, such as Dr. Colin Franklin, Dr. M.A. MacLean, Dr. John Mar, and their supervisors, Mr. Keith Brown and Dr. Langille saw the proposal to build a satellite as just the major challenge they needed, and picked up the idea with enthusiasm. Dr. Warren had complete and unshakeable faith that the Electronics Laboratory was the best in the world and could build one of the most complex satellites ever built at the time. To their credit, the new Chief Superintendent, Mr. J.C.W. Scott, and Mr. F.T. Davies, who had become the Assistant Chief Scientist at DRB HQ, also supported the further exploration of the concept.

There was, however, one major problem: launch. Canada had no launch facilities nor any programs to develop such facilities, and this portion of putting a satellite into space required cooperation from the Americans. At that time, the US was scrambling hard to develop a reliable launch vehicle. As soon as the Canadian concept had been generally fleshed out, Dr. Warren and Mr. Scott went to the Pentagon to try to arrange for a joint topside-sounding project with the US Department of Defense (DoD).

It is said that they were greeted at DoD by a big Texan USAF Colonel, who listened attentively, cowboy boots on his desk and smoking a large cigar, as these boys from the far north explained their proposal. When they had finished, he put his feet down, snuffed out his cigar and said "Sure we'll launch it for you. But there's a new agency just starting up -- called NASA -- who are supposed to do international space research projects.

Probably won't amount to anything, but you'd better go and see them first. But if they aren't interested, y'all come right back and we'll look after you."

Mr. Scott and Dr. Warren went along to NASA.

NASA officials listened to the Canadian proposal with more than a little skepticism. They were convinced that the power and antenna problems involved, and the sheer technical complexity of building this first Space-Based Radar (and a sweep frequency one, as well) was beyond the capability of the western world at that time. International science was a definite plus for the fledgling NASA, however, so they agreed to invite DRTE to join their Topside-Sounder Working Group, and that they would launch the Canadian satellite. They sent the proposal along to the Central Radio Propagation Laboratory (CRPL), at Boulder, Colorado, to examine it for scientific merit and engineering feasibility. The CRPL agreed with the NASA view that the proposal was too ambitious, so their report recommended a fixed-frequency experiment as a first-generation Topside Sounder, and that DRTE "be encouraged to develop its swept-frequency system as a second-generation experiment."

The rest, we can say, is history: the CRPL/NASA fixed-frequency satellite (S-48)* suffered delays, the Canadian S-27 kept more or less to its schedule; S-48 suffered more delays, S-27 was launched on 29 Sept. 1962, to become Alouette I; a complete success and an engineering and scientific coup. NASA admitted publicly afterward that it was one of the most complex satellites ever built at that time, and that both they and CRPL had been so convinced that it could not possibly function for more than an hour or two in space, if at all, that they had made no plans to use the data from it. In fact, Alouette I continued to function and provided a wealth of data for about 7 years before it was turned off from the ground. It was turned on again briefly, during its 10th Anniversary celebrations, and found to be still operational.

The success of Alouette I resulted in the joint US/Canada/UK Alouette/ISIS program, and demonstrated to all including Canadian officials and politicians that Canada was in the high-tech space business. An excellent account of the Alouette ISIS Program is to be found in two publications by Mr. J.E. Jackson**. Mr. Jackson was Chairman of the Topside-Sounder Working Group, and has given a generous and comprehensive account of the Alouette ISIS Program.

The total cost of Alouette I was estimated to have been about $3M, not a modest sum in the late '50s and early '60s. It drained resources from other projects at DRTE, and many scientists not involved in the project were somewhat bitter about their perception of the impact of this high-profile venture on their quieter, less spectacular fundamental-research activities.

This satellite program had another major impact upon DRTE, DRB, and DND. The success of Alouette/ISIS led directly to the creation of the Department of Communications (DOC), and the transfer of DRTE in 1969 to the new DOC to become the Communications Research Centre (CRC).

With Alouette I a complete success, the equally successful performance of the modified Alouette II, and with work well under way at DRTE and in Canadian industry on the next satellite to be developed, ISIS-A, the stage was set for consideration of some fundamental issues with respect to Canada and Space Activities. Early in the 1960's, Dr. Chapman had become Deputy Chief Superintendent of DRTE, had become deeply involved in the Alouette/ISIS program and was a well known figure in NASA and Ottawa for his promotion of Canadian Space activities. Accordingly, in May 1966, the Science Secretariat of the Privy Council office, commissioned Dr. Chapman to chair a study of upper-atmosphere and science programs in Canada and to examine the scientific, technological, economic and social benefits from space science. The other members of the commission were Dr. Forsyth, University of Western Ontario, Mr. P.A. Lapp, DeHavilland Aircraft of Canada and Dr. G.N. Patterson, University of Toronto. Their report to the Science Council of Canada and became known as the Chapman report*. In it, and in the Science Council report "A Space Program for Canada"**, the case was made for a Canadian Space Program, to concentrate on satellite communications, Canadian industrial development, cooperation with other countries, and the establishment of a central co-ordinating and contracting agency for space research and development, to oversee and manage the Canadian space effort.

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* The S-48 was eventually launched two years later to become Explorer 20 (25 Aug 1964).

** "Alouette/ISIS Program Summary", National Space Science Data Center Publication No. 86-09, August 1986; and "Results from Alouette I, Explorer 20, Alouette 2, Explorer 31", National Space Science Data Centre Publication No. 88-10, July, 1988; both by J.E. Jackson, Goddard Space Flight Center, Greenbelt, Maryland. USA.

In typical Canadian fashion, the government accepted the general premise of the report, but did something quite different; it established a new Department of Communications and a Crown Corporation, Telesat Canada. It gave DOC responsibility for the existing Alouette/ISIS program, and to support Telesat Canada with background research and development. It also transferred DRTE, its staff, buildings, resources, and programs to the new Department. to become its research branch, CRC. It insisted that Defence R&D in Communications and other areas then current at DRTE should be continued by CRC for DRB so that facilities and resources lost by DND would not have to be re-acquired.

The transfer took place formally on 1 January 1969 under a "transfer agreement" covered by an exchange of letters between Mr. E. Kierans and Mr. Cadieu, the Ministers responsible for Communications and for Defence. DRTE ceased to exist, and the transfer agreement became the governing document whereby defence R&D was carried out in CRC for DND.

Author's Note:

DRTE had a short, illustrious life. During those 17 years it established itself as one of the foremost research establishments on the continent, on a par with any in the world. This brief historical sketch does not attempt to do justice to the multitude of scientific and engineering achievements that came from the Establishment. That is another story. However the main legacy of the DRTE was not in the research and development that it carried out; it was in the dedication -- almost obsession-- to excellence that DRTE instilled in its member scientists and engineers. As a young scientist in DRTE during the last dozen years of its existence, I can attest (without the embarrassment of claiming any credit for it) to the scientific and professional rigour that was forced upon one by the "atmosphere" of the place. The supervisors, from Section head to Chief Superintendent exuded a confidence that DRTE could do anything (scientific) it set out to do, do it better and more successfully than any other organization, and that if you wanted to be part of this team you had better be certain that your science was impeccable, that your approach left no avenue unexplored, and that you knew your specialty "inside-out". If you did not measure up, you were torn to ribbons when you presented your science to your peers and supervisors. In other words, it was taken for granted that competence and excellence were mandatory and nothing less would be tolerated.

I believe that this legacy, instilled almost unconsciously by the management of the Establishment, was a rare gem, and that it is the reason why most ex-DRTE staff remember the Establishment with such fondness and dedication. I salute the great scientists of DRTE who were able to make it happen. - G.L. Nelms, Sept 1991.

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* "Upper atmosphere and Space Programs in Canada" Science Secretariat Special Study No. 1, Queens Printer, Feb. 1967.

** "A Space Program for Canada" Science Council of Canada Report No 1, Queen's Printer, 1967.

THE DEFENCE ELECTRONICS DIVISION

by

LeRoy Nelms

The Defence Electronics Division had its origins in the 1969 transfer of DRTE to DOC, to become CRC. The transfer agreement between DND and DOC states that DOC would carry out a program of research in Communications "adequate to meet the national need" and would carry out specific Defence Research projects that DND wished to have pursued, with costs recoverable from DND. In this way, duplication of research effort was to be avoided and both departments were to have benefitted from the synergism of defence and civil communications research. It was also agreed that DND was not to pay for generic or basic communications research: that was to be the responsibility of DOC.

To manage this ingenious relationship between DOC and DND, (DOC scientists, facilities, and generic research capability; DND money) a Telecommunication Liaison Office (TLO) was specified in the transfer agreement, to be staffed by DND and located in CRC. The Defence Research Board assigned the overall DND responsibility for this "Recoverable" Defence Communications program at CRC to DREO, with a Telecommunications Liaison office reporting directly to Chief/DREO.

The first TLO was Vern Smith; with one clerk, Rob Simpson. Shortly thereafter, it was decided to build up a research capability at DREO in other electronics-based areas, and Oscar Sandoz transferred to DREO from the DRB-HQ, personnel to start that process. Dr. Walter Surtees also transferred to DREO from DRB HQ to head up what was for a short time known as the "TLO Division" but then became the Defence Electronics and Navigation Division. This Division also took on the Defence Industrial Research (DIR) program headed by Russ Lysons which had been transferred from DRB HQ the previous year. The initial plan was to establish a capability in electronics research related to navigation and other "non-communications" electronics and from which support could be given to the DIR program.

As Mr. Sandoz began the process of hiring staff for the new Division and laying plans for its future, it became evident to him that a major capability was required in DND for Electronic Warfare (EW) research, but, as a result of the DND/DOC agreement, research in military Radar and on some aspects of electronic warfare were carried out by CRC on behalf of DND. The chief of DREO, Mr. Wilkinson, however, agreed that such a capability should be built up at DREO, and that the EW research in CRC under the Recoverable Program should be phased out when the existing work was completed. The exception to this was the Radar Electronic Counter Counter Measures project (the incorporation into one's own radar of countermeasures to the adversary's EW) which was an integral part of the Radar program, and would have to remain in CRC.

This decision met with considerable opposition in CRC, and led to the establishment of a series of discussions between the Chief, DREO and the Director General of DOC (George Hollbrook). The Chief, Research Requirements and Development, for DND, Mr. Fergus Ferguson, was invited to join in the discussions, and they became formal meetings, held at 3 or 4 month intervals. They became known affectionately as the "Troitka" meetings. After DRB was replaced by CRAD as the DND operating entity, Mr. Ferguson became Deputy CRAD (Development) and the meetings were expanded to include the other Deputy CRAD, Deputy CRAD (Laboratories). By this time CRC also had undergone great change; Mr. Hollbrook had retired, and CRC now had several responsible DG's, one of which was chosen by DOC as their representative on the program committee. Not surprisingly the committee then became known, perhaps with Apocalyptic premonition, as the "Four Horsemen".

Once given the mandate to build up an EW capability, Mr. Sandoz set out to hire capable young graduates and to establish laboratory facilities. As DREO to that time had been a chemical, biological, nuclear, and energy-conversion (battery) research establishment, creation of facilities was no simple task. Wet labs had to be torn out and electronics labs built, and electronic test and experimental gear purchased. The cost of these new labs and equipments came as a major shock to the management of DREO, to whom an annual expenditure of a few thousand dollars on new equipment carried an aura of gross extravagance.

Nevertheless, by mid-1973 a fledgling capability was in place. A few impressive new graduates (Keith Hooey, Tim MacKenzie, Trevor Tucker), one experienced scientist (Lyall Rowlandson) and some very competent technicians/technologists (D. Judd, Wendell Carkner, J.J. Renaud, Francois Gautier, Gaston Guerette, Bob Pearce, Pierre Richer) were on staff and some laboratories were in operation. (While Tucker was a new graduate PhD, he did have the advantage of having served as a military officer. His last posting before leaving to obtain his PhD was in NDHQ's Directorate of Electronic Warfare. Ken Peebles was about to return from having completed his Masters Degree at the University of Manitoba, and Alan Johnson was completing a study of Transient Radiation Effects on Electronics, before returning to the Protective Sciences Division. Pearl Hanna and Marie Kennedy (Crawford) were secretaries.

In 1973, Dr. Surtees returned to DRB HQ. "Navigation" was removed from the title of the Division, as it was deemed to be a mature technology, and the DIR function, now headed by Vern Smith, was removed to the Office of Chief, to report directly to the Chief DREO. In the autumn of that year, LeRoy Nelms, who had just completed an assignment in DOC as Deputy Project Manager for the Communications Technology Satellite (HERMES) was appointed Director of the Defence Electronics Division (DED), originally on leave of absence from DOC.

Major (Retired) Ted Thompson joined the Division in 1973-74 after retiring from the Canadian Forces, to become TLO. During his tenure as TLO, the small cell within the Radar Program that was involved in ASW signal processing was phased out, and the staff positions devoted to Radar. The Recoverable Program remained relatively stable for the remaining seven years that the Defence Electronics Division was in existence, at about 55 person years of effort per year. Concentration was on tasking from the Canadian Forces in Terrestrial Communications, Satellite Communications. SARSAT (see later) and Radar. However, during this time, there was a gradual increase in the research carried out under the Recoverable Program, as the missions of DOC and the CRC changed and diverged, as DOC lost some of its interest in doing research that was of prime interest to DND.

The further build-up of internal capabilities in Defence Electronics, now depended on conversion of what few positions became available: despite the acknowledged importance of EW and other new electronics areas to a modern Defence Department, growth would have to be by accretion rather than through a major assignment of positions. The establishment of a new research capability can be approached in several ways. For the Defence Electronics Division, a deliberate decision was taken to follow a high-risk, route. The Canadian Forces (the Navy and Air Force in particular) had shown a keen interest in obtaining immediate technical assistance with their EW problems. Therefore, the approach taken was to throw the staff immediately into a series of tasks for the Canadian Forces, and to use the tasks, and the problems of the customer, as the training ground for the staff. Increased budgets, when they materialized, were to be used to let contracts with Canadian industry and Universities to fill gaps left by staff shortages, and to build up industrial capabilities for DND.

This approach risks a loss of credibility if foolish or inappropriate solutions are to be proposed for any of the tasks, because of inexperience of the staff, however it offered the considerable advantage of a very rapid acquisition of the necessary knowledge and skills to help the military, as it put the new staff in the position of proving their capabilities and potentials as researchers in the open glare of high Departmental visibility. It demands the utmost in dedication, competence and sheer hard work from the new graduates. It also has the considerable advantage of impressing on them the importance of the practical application of their researches to the solution of problems for the operational customers in the Department.

This approach worked!

Through the hard work of the new scientists guided by Lyall Rowlandson and Oscar Sandoz, two important tasks, one for the Navy and one for the Air Force, were undertaken and were completed with resounding success. The Division was on its way.

The Division subsequently expanded into other defence electronics areas in a modest way, as staff positions became available. When Ken Peebles returned to DREO, he began to build capabilities in electromagnetic compatibility, to a large extent through the mechanism of contracts with universities. Technology now allowed, through the use of practical Kalman filtering, a number of important navigation problems to be addressed, so a new navigation lab was established.

In 1974, the Hon. James Richardson became Minister of National Defence, and it was decided that part of the DRE Suffield and the Defence Electronics functions at DREO, as well as the Recoverable Radar program at CRC/DOC would be transferred to Winnipeg to become a new Defence Research Establishment, Manitoba (DREM). Extensive planning was done, a large tract of land was bought in the city, and architectural drawings prepared for the new DREM building (still on file at DREO). The plan has not had active consideration since Mr. Richardson left the portfolio. It did result, however, in termination of DREO's Earth Sciences Division; one result was the transfer of the Remote Sensing Section under Ian Henderson to the Defence Electronics Division, expanding the Division's expertise manyfold and allowing successful completion of the SEASAT Project (see the write-up by Salt and Judd).

The Search and Rescue Satellite (SARSAT)* project, based on some earlier work done at CRC under the Recoverable Program was initiated under Project Manager Rod Hafer of DREO, but with the Technical Office in CRD (and managed on the behalf of the Project Office by Mr. Harvey Werstiuk of CRC). Some of the personnel costs of the CRC contribution were borne by the Recoverable Program.

The SARSAT Project was Interdepartmental (DND leading, with DOC and External-Affairs participation) and International (Canada, the US, and France as the SARSAT partners, with the Soviet Union joining later as a COSPSAS participant). It would be hard to come up with a more unwieldy management arrangement than that which was necessary for SARSAT. One thing that was clear, however, was the Project was a resounding success (nearly 500 people rescued worldwide as a direct result of SARSAT -- not bad for an R&D Project!), all because of the dedication of the staff involved, in-spite-of rather than because-of, the organization.

In 1975, Mr. Wilkinson returned to CRAD HQ to the position of D/CRAD (Laboratories) and Clay Iverson became the Chief of DREO. He immediately went on full-time French-language training, and LeRoy Nelms became Acting Chief/DREO during his 10-month absence. Mr. Sandoz was Acting Director of the internal portion of the Defence Electronics Division, while Nelms continued to handle the Recoverable Program with Mr. Thompson as TLO. Shortly after Mr. Iverson's return, Dr. Nelms went on French-language training (it took him 12 months -- much to Mr. Iverson's delight). Oscar Sandoz continued as acting Director until his retirement in late 1977, at which time Ted Thompson assumed the Acting Director responsibilities, as well as TLO. After Nelms' return, Thompson moved to the EW Section to head up the Communications EW R&D and the TLO position was filled by Lt. Col. (Retired) Ross Abercrombie. Ross continued as TLO until his further retirement in 1988, long after the Defence Electronics Division had ceased to exist.

By 1980, the Defence Electronics Division had reached a size and complexity where it could not be handled effectively by one Director. The Division included about 70 internal staff (as well as the 55 CRC staff involved in the Recoverable Program) and while the numbers of staff would not have been excessive if concentrated in one or two R&D areas, the Division covered too wide a variety of areas; EW (the 3 branches of Radar EW plus Com EW), Electromagnetic Compatibility, Navigation, SARSAT, and the complexities of the Recoverable Program, including a complex and sometimes confrontational management interface between DND and DOC, as well as the diverse areas of technology of Communications (Satellite and Terrestrial) and of Radar, and a growing contractual R&D activity. Consequently, in 1980 the Defence Electronics Division was disbanded in favour of two new entities: the Electronic-Warfare and the Electronics Divisions, and transfer of TLO to the new Office of the Deputy Chief DREO, which carried the responsibility for the Recoverable Program at CRC.

The Defence Electronics Division was in existence at DREO for about a decade. It fostered the growth of the Electronics technologies at DREO, from a zero base to two independent Divisions, and provided part of the foundation for a third, the Program Support (Telecommunication Liaison) Division. The Defence Electronics Division was founded and built on the philosophy that the value and purpose of Defence R&D is in the ability to harness technology for the Canadian Forces from the base of a strong research foundation, and as a corollary, to build Canadian Industrial capability so that DND always has Canadian options available for procurement of advanced capabilities.

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* See the separate write-up on SARSAT by Roy McPherson.

THE ELECTRONIC WARFARE DIVISION

by

Various Authors

ORGANIZATION AND MANAGEMENT OF THE DIVISION - by Donald L. Judd

Defence Electronics Division was disbanded in 1981 and two new Divisions were born; the Electronics Division (ED) under Don McKinnon and the Electronics Warfare Division (EWD) under Alan Sewards. The new EWD was made up as follows: Communications EW (Comm EW) with Robert Inkol acting, Radar Countermeasures (RCM) under Trev Tucker, Radar Electronic Support Measures (RESM) under Lyall Rowlandson, and Systems Analysis under Fred Symons. Electromagnetics under Ken Peebles, Remote Sensing under Ian Henderson, and SARSAT under Rod Hafer formed the new ED.

EWD was bursting at the seams and in November 1981, a new building was begun, to provide adequate office space and laboratory facilities. The building was completed over the winter and EWD vacated T5 and moved into Building 75 in June of 1982.

Pierre Yansouni took over as A/Head of Comm EW from Robert Inkol in 1983 and in 1984, Dr. Frank Palmer joined the Division as Head of this Section. Trev Tucker had left to form his own company, Telemus Electronic Systems Inc. and Dr. Bill Cornish took over as H/RCM. A new Section called Technical Support Unit (TSU) under Donald Judd was created in May of 1981 to bring all technical staff under one supervisor. The Unit eventually was disbanded in 1985.

By 1988, Bill Cornish had resigned to join Trev Tucker at Telemus and Ken McRitchie became head of the RCM Section. Lyall Rowlandson was seconded to CRAD Headquarters and Pierre Yansouni took his place as H/RESM.

In January 1990, Alan Sewards left EWD on the Executive Interchange Program to work at MEL Defence Systems for two years. (MEL was eventually sold by the parent Philips Company and became part of Lockheed Canada.) Dr. Frank Palmer became Director of EWD and continued as Section Head of Comm EW until Dr. Ray Carbonneau took over in January of 1991. Catherine Hutton eventually took over as H/RCM from Ken McRitchie and has continued in that capacity (with a name change to Malone following her wedding in October 1990) to date.

THE TECHNICAL PROGRAM - by Alan Sewards

Much of the work of EWD is classified -- highly classified -- and most of the details cannot be divulged. What follows is an account of unclassified aspects of our work.

Electronic Warfare R & D has a long history in Canada, starting in World War II at NRC. Concentration at that time was on understanding the effects of jamming on your own radar defences and developing counters to the jamming: electronic counter-countermeasures (ECCM) in today's parlance. When the Pinetree and Mid-Canada radar lines were installed the emphasis on this work increased, and shortly after it was decided to transfer responsibility for it to DRTE, with NRC effectively getting out of military R&D. In 1956 the Detection Systems Section was set up within DRTE to develop expertise in EW, particularly ECCM, and to kick-start the process a young scientist, Rod Riordon, was sent to England for a year. He went to the Radio Department of the Royal Aircraft Establishment (RAE), joining the Jamming Section headed by Evan Heaton-Jones at the same time as a new recruit, Alan Sewards, who would later come to Canada.

At the end of his year at RAE, Rod Riordon returned to DRTE with a good knowledge of the jammers being developed for the RAF, which would be expected to be similar to those that might be used against the Canadian radar defences. When two years later, the RAF brought their jammer-equipped V-bomber to Canada for tests against the Pinetree Line in Operation Burnt Cork, Rod and his colleagues participated with an advanced Monitor-Van that they had developed, which measured and characterized the jamming signals.

This Section continued, under Del Hansen, working in ECCM and in jamming characterization, expanding into the development of a battlefield radar detection receiver, the Micradet. Rod Riordon resigned in 1965 to take over the family apple farm, and Alan Sewards joined the section in 1966 on his emigration from UK, working on a battlefield IFF scheme and participating, with Gerry Venier, Keith Lacey and Barry Gordon, in some revolutionary thoughts on applying the new minicomputers to EW receivers. This work was continued under Keith, as Project Zander, supported by the Canadian Navy. In 1970, Alan Sewards (who had taken the $1000 cure to UK) returned and took over leadership of the project, which became Project Ogee, the forerunner of the CANEWS ESM system, in use today on all Canadian warships. When the Ogee prototype was completed and successfully demonstrated to the Navy (with the trials assistance of the UK Admiralty Surface Weapons Establishment), this project was formally terminated and the workers reassigned to other areas.

The Canadian Forces (Navy) continued the development of CANEWS at Canadian Westinghouse Ltd. and MEL Ltd. (UK), leading to a Service Test Model in 1980, which was subjected to technical evaluation trials with the assistance of the EW sections of DREO Defence Electronics Division. Following these successful trials, the Navy decided to procure the system and, after a Procurement Review Committee evaluation, MEL UK set up a Canadian Subsidiary, MEL Defence Systems Ltd., in Stittsville, to manufacture the new CANEWS system for the Navy's DELEX and DDH-280 programs, thus creating the first Canadian all-EW company.

In 1981, as noted elsewhere, the DREO Defence Electronics Division was disbanded and the EW portion replaced by a new Electronic Warfare Division. The new division incorporated the Radar Countermeasures Section from DED, under Trev Tucker, the Radar ESM Division under Lyall Rowlandson, a Comm EW Section temporarily headed by R. Inkol, and a Systems Analysis Section under Fred Symons. Don Judd headed a Technical Support Unit. Alan Sewards, who had joined DREO from CRC after a stint doing satellite communications work, was appointed the first Director of the new EW Division.

With a large demand for EW expertise building-up from the Canadian Forces, CRAD agreed to a build-up of staff, and provided substantial funds to augment in-house capabilities by contracting out R&D to the fledgling Canadian EW industry. EW Division thus became one of the first units of a Defence Research Establishment to get involved in what later became a formal government contracting-out policy.

The Division at that time was housed in the less-than-satisfactory temporary accommodation known as T-5, and the expansion quickly outgrew available space. The Chief, Clay Iverson, recognizing this, engaged in some financial sleight-of-hand in the fall of 1981, which resulted in Building 75 being built for the modest sum of $1.9M, in record time and the Division thankfully moved in June 1982.

Frank Palmer was appointed Head, Comm EW Section in 1983 after a selection process that broke all records for its slowness. He had come from CRC via a stint at CRAD HQ in DSP.1. One of his first tasks was to make some difficult decisions on the future of a project that had been ongoing for several years - a very novel communications-emitter locating system which used time-difference-of-arrival techniques. His new programs concentrated on satisfying the Canadian Forces new Land Requirements, principally the detection and location of frequency-hopping radios. At about the same time, Pierre Yansouni also joined Comm EW Section from HQ.

During the early '80s, a steady build-up of staff had occurred and the Division took on increasing responsibilities for the R&D needs of all three elements of the CF, and also for the Communications Security Establishment (CSE). The Division also built up a solid relationship with Canadian EW industry through its substantial R&D program operated by contract.

In the mid-'80s, several scientists left the Division. Trev Tucker went to CRAD HQ and, in 1985, left the government to form Telemus Electronic Corp., to develop and manufacture digital RF memories and other microwave EW devices that had been invented in his Section at DREO. He was followed to Telemus by Bill Cornish, who had succeeded him as Head RCM Section. Around the same time, Larry Conway and Paul Pulsifer, also of the RCM Section, left to join MEL Defence Systems. John Moffat was lost to CRAD HQ, to

DRDA; Ken McRitchie took over as Head, RCM Section in 1986 with the difficult task of rebuilding the Section and its program after all this major loss of experienced staff.

In 1987 Lyall Rowlandson resigned from his long-standing leadership of the RESM Section to take up consultant status in the Division. Subsequently, he was seconded to CRAD HQ to assist in the re-start of the Defence Industrial Research Program. Pierre Yansouni won the competition to succeed Lyall as RESM Section Head in 1988, assuming responsibility for the R&D that was well underway on a mid-life upgrade for CANEWS, known as CANEWS-2. This work, which encompassed acousto-optic receivers, novel applications of expert systems, custom integrated-circuit designs, and extensive software, was done from the start in association with industry, with the goal of facilitating technology transfer when the time came.

Ken McRitchie, having rebuilt the RCM section, decided that individual consulting work in RCM was more to his taste and handed over the section to Catherine Malone in 1989. In early 1990, Alan Sewards resigned the Director's position to take an Interchange Canada assignment with MEL Defence Systems for a 2-year period as Chief Scientist. Frank Palmer won the competition for Director and the resulting vacancy for Head Comm EW Section was filled by Ray Carbonneau from HQ. This re-staffing set the scene for the Division's moment of glory during Operations Friction and Desert Storm, during which they provided substantial and critical support to the Canadian Naval and Air-Force Elements serving in the Persian Gulf.

DREO'S SEASAT PROJECT - by Jim Salt and Don Judd

The SEASAT Project, initially, was conceived to use a satellite to "photograph" 100-km wide swaths across the face of the planet. The basis of the plan was to use optical-signal processing techniques to process the data from a Synthetic Aperture Radar (SAR) imaging system to create a "photographic" record of selected areas on the earth's surface. This was a multi-national project and the major participants were: - The USA; Jet Propulsion Laboratory (JPL) in California, and the Environmental Research Institute (ERIN) in Michigan; - The UK; the Royal Aircraft Establishment (RAE); and - Canada; DND/DREO; Earth Sciences and Defence Electronics Divisions. All the participants had been active in remote sensing R&D and a joint development effort was mounted by all so that the SEASAT satellite, scheduled to be launched by the US in May of '78, could lift off on time. There were, however, some technical difficulties with the launch apparatus and lift-off had to be postponed until July of that year.

The Remote Sensing Section of DREO's Earth Sciences Division had accepted responsibility for development by contract, of a suitable recorder and signal processor, both using optical techniques, to be used for capturing in real time the radar signals from the satellite and for later processing of the acquired information. The designs were innovative and the research and development aspects were difficult and "in practice" proved to be too much for private industry. In view of the international commitment made by Canada to support the SEASAT Project, Canadian manager, Dr. LeRoy Nelms, Director of the Defence Electronics Division, decided earlier to undertake the in-house development of a back-up recording system, drawing on the skills and technical expertise of many individual scientists and technical divisions. Dr. Nelms selected Don Judd to coordinate all the effort placed into this project by the many technical staff. Because of this back-up work, Canada had two systems, an optical data recorder and an optical signal processor to produce SAR imagery from the Seasat Satellite in place at Shoe Cove, Newfoundland, in time for the July launch of the Satellite. Don ultimately received a DND ADM(Mat)Gp Certificate of Merit for his work in having the project completed on time and in-place, as Canada had promised.

The optical film recorder was conceived based on a previous instrument built by ERIM. Specifications of performance were developed by Nicole Brousseau and Barry Felstead (CRC). The mechanical design which involved accurate transportation of a 5" wide photograph film of some 200 feet length was devised by Dave Hidson and Vic Pede. Lyall Rowlandson and Myles MacMillan were some of the electronic geniuses, Nicole Brousseau and Jim Salt controlled the optics. Don Judd acquired all kinds of electronic/electrical equipment and coordinated construction. Bill Dickson was responsible for the construction and machining of many mechanical parts. Many other individuals were heavily involved, and are listed on the next page.

This optical recorder was designed to record the demodulated downlink signal from the SEASAT satellite via a receiver and satellite dish. The dish was located in Shoe Cove, Newfoundland, the installation of which involved fog-engulfed journeys and unforgettable visits to the Rock by many employees. The demodulated SAR signal was displayed on a precision cathode-ray tube as a very small spot which was swept across the screen with its motion and intensity imaged onto moving film that was driven in synchronism with the satellite as it passed over Canada. This was a real time recorder of extremely high density data. Simultaneously an Arvin Echo magnetic tape machine was installed as a secondary back-up recorder at Shoe Cove to record SAR data electronically and frustrate the staff.

The resulting exposed film, when processed by National Air Photo Library (NAPL), was a one-dimensional hologram or an interferogram. Its format was unintelligible to the human eye. The film was then ready for the optical processor which transformed the miles of interferograms into spectacular imagery of mountains, valleys and seas.

The second stage of this project involved an optical processor of which two versions were built; one in-house and the other under contract. Initially, a static 'in-house' system that did not transport the interferogram but took snapshot photographs, was built at DREO in the optics lab of the Remote Sensing Section. Images of the Labrador coast were produced as proof of concept. Further design work by Claude Brochu and Nicole Brousseau using computer simulation techniques developed the technology used by CIR Ltd to construct under contract a dynamic system producing continuous imagery of 50- to 75-Km wide swaths and hundreds of kilometers long. The system was installed at DREO, in Rm 13 of Bldg. 5, and was lovingly operated by Debbie Roberge (nee Duston) for a period of two years under contract.

Hundreds of metres of imagery representing thousands of square hectares of land coverage were produced by Debbie. The imagery produced was standardised at about 10 metre resolution from a satellite 600 miles high. With patience Debbie was able to produce some imagery with 3 metre resolution. Photographs of the imagery produced in the static system (Labrador Coast) was close to being the first imagery from any source, and photographs with the dynamic system were demonstrated world-wide.

Unfortunately "Seasat" had a life span of about only three months. The amount of imagery of the earth's surface was prolific and its quality was amazing. A good recorder/processor on the ground was capable of resolving one-metre objects from the space data. In October of 1978, after producing volumes of information, the SEASAT Satellite died of "heart" failure when its back-up power supply became non-operational. But, in spite of this infant mortality, researchers are still analyzing the "photographs" some thirteen years later, so the experiment must surely be deemed to be a success.

DREO staff and others involved in this unique project are listed below. Our apologies to those omitted!

Earth Sciences Division

Ian Henderson
Nicole Brousseau
Jim Salt
Claude Brochu
Red Apps

Defence Electronics Division

Don Judd
Lyall Rowlandson
Miles MacMillan
Doug Difruscio
Jim Lee
Bob Pearce

Other DREO

Daniel Boivin
Sylvain Bouchard
Francois Gauthier
Will Janssen
Brian Kozminchuk
Francois Paquet
J.J. Renaud
Pierre Richer
Fred Symons
Graham Thistle
Bev Young
LeRoy Nelms
Ian Henderson
Donnalee Desaulniers
Gaston Guerette
Cathy Hutton
Ken Haley

Protective Sciences Division

Vic Pede
Dave Hidson
Bill Dickson
Jean Baillot
Larry Constantine

Other-Agency Staff included:

CRC

Darryl Barnes
Barry Felstead
George Haslam
Don Page
Al Gagnon

Shoe Cove Operational Staff (NORDCO)

Richard Terry
Gord Pike
T.L. Duffield

SeaSat/CCRC

Al Collins
Capt. R. Maxwell
Ron VanKoughnett
Keith Raney
Ed Shaw
Ed Langham

CIR

Mike Failes

THE ELECTRONICS DIVISION

by

Various Authors

INTRODUCTION - by the Editors

The Electronics Division is one of the two Divisions which arose from the disbanding of the Defence Electronics Division in 1981. The former Electromagnetics and Remote Sensing Sections, the SARSAT Project Office, and the Technical Support Unit (Microwave) formed the new Division and the early technical program was an extension of the previous programs of its Sections. This included: R&D on navigation systems, remote sensing systems, electromagnetic compatibility, protection of electronics systems from nuclear effects, participation in satellite-aided search and rescue, satellite communications, and space-based-radar surveillance. These programs are current to this day, although the SARSAT project is finished, and is in the process of being terminated. The Division has taken over the Nuclear Effects program from Protective Sciences Division and has added the responsibilities for the programs on effects of nuclear weapons on personnel, on nuclear shielding, and on radiation biology.

The first director of the new division was Don MacKinnon who had transferred to DREO from CRAD HQ to head the new division. Following his retirement in late 1986, he was succeeded by LeRoy Pearce. In 1989, LeRoy accepted an appointment to CRAD HQ and Bill Hindson became, first, the acting director and then, in 1991, the director. Secretaries in the division have been Donna Findley, Faith Stiles, Marylou Bowden, Kathleen McHale (Anderson), Roseanne Carroll, and with the transfer of Nuclear Effects personnel to the division, Mary Anne O'Keefe and Ann Gill.

No account of the overall technical work of the Electronics Division has been received, however Mike Vinnins and Roy McPherson have submitted short write-ups on the Navigation Program and on the SARSAT projects respectively. The work of the Nuclear Effects Section and its Subsection on Radiation Biology have been included in Charlie Clifford's account of the Protective Sciences Division.

THE DREO NAVIGATION PROGRAM - by Mike Vinnins

The navigation program was founded in 1977 with the aim of 'developing a technology base in navigation, components and systems in support of Canadian Forces requirements'.

The group began in the Defence Electronics Division under the Electromagnetics Section (EMS) headed by Mr. Ken Peebles and supported by the 'faithful' secretary, Faith Stiles. The first two 'navies' (attached naval officers) in the group were Barry Fletcher and Lt Michael Vinnins who began work in June of 1977.

Initial tasks consisted of support of a DND contract with Canadian Marconi Company for the development of a GPS receiver and an in-house technology base activity aimed at developing expertise in the (new) field of strapdown inertial navigation components and systems. The group grew as Dr. David Liang arrived from DREV and Dr. Prakash Bhartia joined from the University of Manitoba. They were followed by Larry Engel, David DiFilippo, Christopher McMillan and Jeff Bird over the next several years. This added expertise permitted expansion of work into new areas; in particular, integrated systems. Programs in the early

1980's included the Marine Integrated Navigation System (MINS), the Primary Land Arctic Navigations System (PLANS) and the CSG-2 program (development of a high-performance two-degree-of-freedom gyroscope).

In-house laboratory capabilities were initiated in March of 1979 with the opening of the DREO Inertial Navigation Laboratory staffed by Mike Vinnins, Barry Fletcher and David DiFilippo and ably assisted by Pierre Richer (stolen from Don Judd's technologist's pool).

Ken Peebles left in 1979/80 and Prakash Bhartia assumed leadership of the Section. Under his tutelage, programs such as MINS, PLANS and the CSG-2 flourished. Laboratory and field trial work escalated and more technologists were recruited including Red Apps, Alan Walsh, Bill Barnes, Francois Paquet and, of course, Lloyd Gallop. All were veterans of one or more dead or dying divisions or sections.

Dr. Bhartia left for a 'career advancement' at HQ in 1985 and was replaced by David Liang as Section Head.

At about that time, the section's name was also changed to 'Navigation and Integrated Systems Section' (NIS). MINS became a resounding success, was transferred to industry and put into production for installation on all Canadian naval vessels.

New programs were developed, to utilize the technical expertise which had been built up by MINS. These included the Helicopter Integrated Navigation System (HINS), and work on the CP-140, laser gyroscopes. The development of an in-house-designed (and built) Heading Reference Unit (HRU) for use in land-vehicle applications was successful and DREO built the prototype.

The section's situation took a turn for the worse in 1990. Cutbacks in CRAD funds resulted in a 'review' of the navigation program, and a committee recommended the termination of the program with the remaining personnel (5 DS's and 5 technologists) were to be dispersed to other sections. The program was re-reviewed early in 1991 and in June of 1991 CRAD miraculously re-instated the navigation program, albeit in a reduced format. Four people remain in the 'Navigation Group' as part of the Communications and Navigation Section (CNS) (formerly EHF SATCOM).

Chris McMillan and Jeff Bird continue work in integrated systems while Mike Vinnins and Lloyd Gallop maintain tech-base laboratory-based development and field-trial capability.

Recently a Memorandum of Agreement was undertaken with Carleton University for shared use of laboratory facilities and expertise. This is expected to enhance DND navigation capabilities in the coming years.

The group's future appears bright: numerous areas of technology promise exciting future R&D work.

SARSAT - by Roy McPherson

The Search and Rescue Satellite Tracking (SARSAT) Project was an international effort to demonstrate the use of satellites to locate aircraft and ships in distress, faster and with greater accuracy than by current conventional means.

DND first considered the potential for a satellite-aided tracking system in 1972. It asked DOC and private industry to study the use of polar-orbiting satellites to improve detection of distress signals from both land and sea locations. The OSCAR program, carried out by the DOC/CRC in the mid-'70s, demonstrated the system's technical feasibility.

By 1978 considerable interest had been shown by Canada, the USA and France in supporting an international demonstration of the system concept. That same year, CRAD sponsored Canada's SARSAT

Project and assigned it to DREO. DREO established a project team of Rod Hafer (the Project Manager), Harvey Werstiuk (DOC/CRC), the Technical Manager, and Roy McPherson, Deputy Project Manager and System Evaluation Manager. The following year Treasury Board approved the Canadian project and later, in the same year, signed an international Memorandum of Understanding. The other SARSAT parties were France and the USA. In parallel, another MOU was agreed to between the SARSAT Project and the Soviet Union, representing the equivalent Soviet Project (COSPAS).

The technical basis of the system is as follows: Emergency Locator Transmitters (ELTs) introduced to the North American civil aviation community in the early 1970s, ensure rapid notification of a distress situation and provide a homing ability. The marine equivalent is the Emergency Position Indicating Radio Beacon (EPIRB). Working with existing ELTs and EPIRBs, the satellite acts as a simple repeater. It receives the ELT transmission and re-modulates it onto a down-link signal carrier. On the ground, the signal is received at a Local User Terminal (LUT). Here the uplink Doppler shift is measured as the satellite passes the ELT. This information, plus accurate knowledge of the satellite orbit, allows the calculation of the latitude and longitude of the ELT location. This calculated location then is relayed via the Mission Control Centre (MCC) to an appropriate Search and Rescue authority for action.

Canadian industry contributed significantly to the Canadian portion of the system's hardware. SPAR Aerospace of Montreal built the repeaters that Canada provided for integration on the American satellites. Canadian Astronautics Ltd of Ottawa built the LUT that was installed at DREO. They also provided LUT's to the U.S. SED Systems Ltd. of Saskatoon designed and built the MCC that the project installed at CFB Trenton adjacent to the Trenton Rescue Coordination Centre (RCC).

The technical verification of the joint COSPAS/SARSAT system began with the launch of the first spacecraft, COSPAS-I, by the Soviet Union in June 1982. This was followed by the launch of the second Soviet satellite, COSPAS-II, and the first SARSAT satellite, SARSAT-I (NOAA-8), in March 1983. A series of technical system performance tests were then completed to confirm proper functioning of the system. A Demonstration & Evaluation phase began in February 1983, with the active participation of user services. COSPAS-III was launched in June 1984 followed by SARSAT-II (NOAA-9) in December 1984. The Demonstration and Evaluation was completed in mid 1985.

In its earliest days in space, and while still in its R&D phase on 9 September 1982 (less than 3 months after COSPAS-I was launched), a small aircraft crashed in a remote mountain valley in Northwestern B.C. The plane was 90 kilometres off its planned route and rescuers faced days of frustrating searching of many square miles of extremely rugged terrain before they would have found the crash site. Instead, COSPAS-I detected the ELT transmission and relayed it to the LUT at DREO. After processing, the location data was sent to the MCC at CFB Trenton which, passed the information to the local RCC for action. Within hours, the survivors were being airlifted out from the crash site to safety, demonstrating the practicality of the system. Stories of this nature were to be repeated over and over. By the close of the evaluation in 1985, the system had provided alerting-and-location data for some 194 distress incidents world-wide, involving 529 people, of whom nearly 500 were rescued.

DREO completed its role in the project in 1985 with the establishment of an Interim Operational System, managed by the CEM Branch. Its task was to give full Canadian ground coverage from installed and upgraded LUTs in Edmonton, Churchill and Goose Bay. The MCC facility at CFB Trenton also was upgraded to operational standards and approval was given for Canada to provide instrumentation for additional satellites.

In the summer of 1991 the DREO effort came to fruition: the Canadian SARSAT system was declared fully operational and passed into the realm of the day-to-day operational technology of search and rescue.

THE RADAR DIVISION

by

David DiFilippo*

1951 TO 1974

The Radar Division at DREO has its historical roots in the Microwave Fuzing Group of DREL which later became EL. Its history, including its amalgamation into DRTE, has been described above. This Microwave Fuzing Group was formed in 1951 to design and develop a microwave proximity fuze for the Velvet-Glove missile. This was an air-to-air missile that was being developed at Canadian Armaments Research and Development Establishment (CARDE), the predecessor to DREV. The function of the microwave fuzing system, located on the missile, was to detonate the missile when it was within a certain distance of its target, as determined by microwave measurements. By 1955, the group had developed successfully the fuze technology and transferred it to Canadian Westinghouse. They built 64 microwave fuzes which were shown to operate satisfactorily in trials at Picton, Ontario. The fuze design was then handed over to CARDE, who had overall responsibility for the Velvet-Glove project.

The Microwave Fuzing Group then became the Radio Warfare Section, which reflected the shift in focus to the pressing Electronic Counter Counter Measures (ECCM) problems of the day. With this new mandate came a new location: in 1955, the Radio Warfare Section was moved to the new DRTE at the Shirleys Bay site, where it occupied the first floor of Bldg 4. The rest of EL was not moved until about 1961.

The intense interest in ECCM at that time resulted from the development of a new type of Carcinotron jammer, a powerful microwave source that was capable of being noise modulated over a wide bandwidth that, as it turned out, happened to encompass all frequencies employed by the North American air defence radar systems. This was developed by the French company, CSF, under contract to the UK Royal Aircraft Establishment, in 1954. There was grave concern that the device could be used by hostile forces to jam these air-defence radars, heightened by the fact that the work by CSF had not been classified. In fact, full engineering details of the Carcinotron were published in the open literature and this situation was putting great pressure on Western-world scientists to develop ECCM systems to help alleviate this threat.

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* Acknowledgements

This account of the Radar Division history has been pieced together from the recollections of many people, including Frank Smith (who contributed most of the information in Part I), Darrell Barnes, Gordon Marwood, Bert Bridgewater, Malcolm Vant, Ross Turner and Alan Sewards. Their interest and willingness to provide information was greatly appreciated. At the same time, apologies go out to anyone whose contributions to the rich history of this Division may have been overlooked; unfortunately, such oversights are inevitable when the writing of history is attempted by amateurs.

Over the years, many secretaries have endured the demands (for those who dared to demand) and idiosyncrasies of the Radar Division staff. Surprisingly though, most of them stayed with the Division for many years. These secretaries have included Mary-Lou Fortier, Bev Lake, Judy Bruce, Judy Thain, Mary Gottselig, Denise Stewart, Michelle Vinnins, Faith Stiles and the current record-holder for longevity in the Division, Darlene Lacroix.

Canadian ECCM activities involved the ECCM Section of DRTE and the Electrical Engineering Divisions of NRC. Project "Napkin" was instituted to coordinate the Canadian effort. From 1955 to 1963, the Radio Warfare Section carried out a variety of ECCM related activities. One group, led by Lyall Rowlandson, concentrated on the design and development of receivers employing the "Dicke-Fix" ECCM technique. Another group, under Walter Searle, worked on developing an airborne device for tracking airborne Carcinotron-type jammers. Rod Riordon was sent to the UK for a year, where he helped in the development of jammers for the Royal Air Force, becoming familiar with Carcinotron jammer techniques and jammer flight trials in the process. Frank Smith investigated the problem of predicting the instantaneous power spectrum of the Carcinotron jammer, which was difficult because it had nonlinear tuning characteristics.* Internationally, there was great cooperation between Canada, the US and the UK in evaluating the effects of the latest Carcinotron jamming systems on the North American air defence systems - in particular, the Pine Tree Radars in Canada and the SAGE system in the US. Canada's main contribution to these jamming trials was a ground-based monitoring system, capable of tracking the airborne jammer and automatically measuring the output power spectrum. This ground-based monitor was supplied by the Radio Warfare Section, with Frank Smith providing the specification and R.F. Nikkel and his group designing and building the monitor. These trials also led to more Canadian - US cooperative work in ECCM. The combination of the Canadian effort in the design of Dicke-Fix receivers and the US development of Constant False Alarm Rate (CFAR) techniques made for a much better understanding of radar system performance in Carcinotron-type jamming environments. It is particularly noteworthy that the Dicke-Fix receivers developed by the Radio Warfare Section were eventually produced by Canadian Arsenals and installed in the Pine Tree Radars.

By 1963, the work in ECCM was winding down. In that year, the Radio Warfare Section was reassigned to the Communications Laboratory. Over the next few years, the Section went through a series of name changes: Radar Systems Section, Detection Systems Section, and finally, Radar Section. From 1963 to 1969, the Section addressed a number of diverse radar- and signal-processing problems. Art Poirier and Darrell Barnes designed and built a compact microwave-detection receiver, for use by army personnel in detecting illumination from hostile battlefield-surveillance radars. The production version of this receiver, manufactured by Canadian Arsenals, was put into service in the Canadian Army. Keith Lacey, Barry Gordon, Alan Sewards and Gerry Venier worked on ideas to automate Electronic Support Measures (ESM) processing using the new British UAA-1 ESM receivers and the commercial minicomputers just appearing on the market. Frank Smith, with support from Reg Cross and Len Taylor, investigated the problem of detecting small aircraft with a noncoherent ground-based radar in a severe clutter environment. This was a serious problem particularly relevant to the existing Air Traffic Control Radars at CF and NATO air bases. Alf Gilchrist and Fred Symons worked on Project "Tandem", which was a project to develop Fast Fourier Transform (FFT) signal-processing techniques for hydrophone arrays to be used for passive-sonar detection of submarines; Bert Bridgewater later worked on active-sonar detection tracking techniques. (Although the application was not radar-related, the signal and data-processing techniques developed were applicable to radar.) During this period, the Radar Section provided technical advice to DND on many problems encountered with their existing radar systems, and also evaluated various radar systems proposed for future procurement.

In 1969, with the transfer of DRTE to CRC, Radar research continued, although there was no requirement for such research in DOC. F.T.Davies, the chief superintendent of DRTE, had insisted that DRTE be transferred as a whole, fearing that fragmentation would destroy the research establishment that he had supervised and nurtured for so many years. Consequently, the Radar Section, although now part of DOC, continued to be largely supported by DND.

At approximately the same time, the Radar Section expanded, incorporating the Basic Circuits Group from the Electronics Laboratory. Because of space limitations in Bldg 2B, the Section was now split up. One group, led by Alan Sewards, remained in Bldg 2B. Another group, under Bill Hindson, relocated to Bldg 13 (which, they were told, was to be only a "temporary" accommodation for a few months - little did they know.) The group in Bldg 13 concentrated on problems related to airborne radar. The group in Bldg 2B continued to work on ESM for the navy, embarking on a collaborative project with the UK that involved development by Canada of a digital-processing subsystem for British ESM equipment. (In the UK, the project was led by Gordon Marwood, who would join this group five years later.) In support of this effort, joint sea trials (of which Ross Turner and Art Poirier retain particularly fond memories) were held in Canada and Europe. In 1973, this work was completed and handed over to the newly-formed Electronic Warfare (EW) Section at DREO, where it would eventually lead to the development of the CANEWS (Canadian Electronic Warfare System). With the mandate for all EW work now transferred back to DND, the group shifted its focus to surface radar problems.

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* Smith soon realized that the relatively new fields of statistical communications and information theory were not yet advanced enough to solve this problem, and furthermore, that Canadian expertise in these important theoretical areas was seriously lacking. Through Smith's initiative, a Statistical Communications and Information Theory Group was formed at Queen's University in Kingston. For many years, there was close cooperation between this group and DRTE; DRTE supplied the university with many problems suitable for Masters and PhD theses, and graduate students and graduates from the group worked at DRTE. In 1968, Paul Wittke, as a PhD student in that group, solved the original problem posed by Smith and generalized the theory in his PhD thesis. This group at Queen's is still flourishing today, although the contact with DND no longer exists.

In 1974, the Radar Section was large enough to be split off from the Communications Laboratory, and became the Radar Research Laboratory (RRL), with Frank Smith as its first Director. The Bldg-2B Group became the Surface Radar Section, led by David Mabey, and the Group in Bldg 13 became the Airborne Radar Section, led by Don Page.

In that same year, the RRL staff were shocked when the Minister of National Defence announced the new DREM, to be built in Winnipeg, would include RRL, it being one of the elements that would be transferred there. This proposed move resulted in a major turnover of personnel, as many RRL staff who did not wish to relocate left CRC.

1974 TO PRESENT

From 1974 to the present, radar research continued within the framework provided by the Airborne and Surface Radar Sections. In May 1988, the RRL was repatriated to DND and DREO, where, it became the Radar Division. This transfer, however, did not affect significantly the projects that were underway in the two Sections.

LEADERS OF THE RADAR DIVISION (INCLUDING ITS PREDECESSORS)

The various leaders of the Radar Division and its predecessors throughout the years are listed in chronological order:

pre-DRTE

Leader of the Microwave Fuzing Group	Irv Paghis

DRTE 1951-1969

Heads of the Radio Warfare Section	Roy Dohoo Irv Paghis Keith Brown Jerzy Miedzinski

CRC - 1969-1973

Heads of the Radar Section, Detection Systems Section, etc.	Del Hanson Don Page

CRC 1974-1988

Directors of the Radar Research Laboratory	Frank Smith ('74-'78) Alf Gilchrist ('78-'79) David Mabey (acting,'79-81) David Mabey ('81-'88)

DREO 1988-1991

Directors of the Radar Division	David Mabey ('88-'90) Gordon Marwood (acting '90) Prakash Bhartia ('91)
Heads of the Airborne Radar Section	Don Page (CRC '74-'80) Rob Gray (CRC '80-'88) Malcolm Vant (DREO '88-'91)
Heads of the Surface Radar Section	David Mabey (CRC '74-'81) Gordon Marwood (CRC '81-'88) Gordon Marwood (DREO '88-'91) Bert Bridgewater (DREO, acting '91)

AIRBORNE RADAR SECTION - by Malcolm Vant

Initially, the Airborne Radar Section continued work that had begun in 1971 in support of the Canadian Sensors Familiarization Program. This program was established to allow Canadian defence scientists to become knowledgeable about various candidate sensors for the new Long Range Patrol Aircraft. The Airborne Radar Section was involved in technical and operational evaluations of airborne radar sensors - in particular, the AN/APS-94 which was a Side Looking Airborne Radar (SLAR). In 1974, a major project was begun to modify the APS-94 to add a coherent capability to it. This work, successfully completed in 1979, involved a number of people: George Haslam, Bill Hindson, Darrell Barnes, Al Gagnon, Paul Xhignesse, Ray Burrill, Ron Martin, and Ross Fines.

Out of this work on the APS-94 grew the idea of modifying the APS-506 search radar on the CP-140 patrol aircraft to incorporate a spotlight Synthetic Aperture Radar (SAR) mode for high-resolution imaging and classification of ships at long range. The Section had gained credibility in this area from its work on the APS-94 and on the digital signal processor for the SAR on the SEASAT-A satellite. SEASAT-A was a NASA satellite whose primary role was to collect remote-sensing data for ocean studies. The Section's involvement with SEASAT-A began in 1975, when two employees from MacDonald Dettwiler and Associates (MDA) came to work with the Section for six months to learn about SAR, in preparation for an MDA bid on the hardware digital processor for SEASAT. Although NASA ultimately decided to go with optical SAR processing, MDA was given a contract to build a software processor for Canada, and went on to become a major industrial company in the area of satellite SAR ground stations. By 1976, the Airborne Radar Section was no longer directly involved with the MDA work, but instead began developing its own software-based SAR processor for SEASAT. This processor was the first in the world to process SEASAT data to its full resolution of 7 metres in cross-range. This work, completed in 1979, signalled the start of the Section's work on digital SAR processing. Malcolm Vant (who joined the Section in 1976) and George Haslam were responsible for much of this work. This processor eventually was modified to process airborne data from a variety of SARs. Using it, the Section was able to demonstrate a world-class capability in this area.

During the same time period, Rob Gray started his work on clutter modelling. This work lasted from about 1978 until his departure in 1988.

In 1980, the Section obtained approval for the ten-year $12-million Spotlight SAR Exploratory Development Project. Its goal was to modify the APS-506 search radar and add a real-time capability, based on SAR, for long range classification of ships. George Haslam was the overall technical manager for the project, and in addition, was directly involved in designing and implementing substantial modifications to the APS-506 hardware to accommodate a SAR mode. Malcolm Vant was responsible for the design and development of the real-time airborne SAR signal processor, with support in the early stages from Kam Wu. The SAR processor featured three imaging modes: a strip-mapping mode, a spotlight-SAR mode, and an inverse-SAR mode. David DiFilippo (who at that time was with the Electronics Division at DREO) worked on the development of a real-time SAR motion-compensation subsystem to compensate the SAR signals for spurious motion of the airborne radar antenna. Ray Burrill was involved in the development of the SAR data-collection subsystem. Darrell Barnes was responsible for coordinating all aspects of the Spotlight-SAR flight trials (of which there were several hundred hours worth) and for supervising the efforts of several staff who provided valuable technical support to the project, including Ray Burrill, Al Gagnon, Paul Xhignesse, and more recently, Larry Ryan. The project also involved heavily, contractors such as MDA, Computing Devices, W. E. Thorp, Huntec, and Array Systems Computing. This project was completed successfully in 1990, with the demonstration of real-time operation of the complete system on board a Convair-580 research aircraft, owned by the National Research Council. The completion of this work involved the solving of several tough technical problems, and in solving these problems, the Section and the individuals involved gained a world-wide reputation in this area. The Spotlight-SAR system has been selected for the planned CP-140 upgrade.

In parallel with this work, efforts have been underway to model the SAR returns from ships, and classify them automatically. Work has been done on the modelling of ship wakes and the automatic detection of wakes in SAR imagery. The use of polarimetry as a target discriminant in SAR imagery has also been investigated. These efforts involved several firms and were led internally by Malcolm Vant, Kam Wu, Maria Rey, Bob Klepko, and more recently, Anthony Damini. A contractor, London Research and Development, has developed considerable capability in this area, as a result of its work with the Section.

During the mid-'80s, Malcolm Vant and Rob Gray also were involved heavily in the Canadian Radarsat Project. Rob Gray had responsibility for the SAR system, and Malcolm Vant for providing expert advice on the SAR processor. When Rob Gray left in 1988, and the RRL was transferred from CRC to DREO, this work was scaled down.

In 1988, a new group under the leadership of Denis Faubert was created to study aspects of pulse doppler radar. This represented a new area of research for the Airborne Radar Section, which, from the mid-'70s until then, had concentrated mainly on SAR. This group was built up with the addition of several new people to the Section: Gary Vrckovnik, France Tremblay, Glen Rempel, Rob Robinson, and more recently David DiFilippo, who transferred from the Electronics Division. This new group is working on a variety of projects: aircraft identification through jet engine modulation techniques, a missile-approach warning system for fighters, and electronic counter counter measures for pulse doppler radars. Denis Faubert left DREO for DREV in the spring of 1991, and David DiFilippo has since taken over his position.

SURFACE RADAR SECTION - by Bert Bridgewater

The Adaptive Radar Project, begun in 1973, was the first major initiative undertaken by the new Surface Radar Section, and signalled the start of their work in phased-array radars. The heart of this system was an S-band space-fed-lens antenna, obtained on permanent loan from the UK (a very tangible result of TTCP collaboration). Art Poirier, Grant Duff, and Bob Noyes developed the computer-control and data-collection subsystem; Ross Fines and Len Taylor developed the RF subsystem. Various experimenters became involved in exploiting the special features of the Adaptive Radar Facility. Ross Turner demonstrated how phase-only adaptive nulling could be achieved using the coarse phase-control available on the radar antenna. Eric Hung showed how to carry out in-situ array calibration using a space-fed lens. John Bird developed techniques for the extraction of coherent clutter returns, and for Doppler processing and detection of moving targets. He also demonstrated ISAR-imaging techniques using targets of opportunity. Mark Gregoire and Bert Bridgewater combined the ISAR software with routines for surveillance and tracking to produce the Automated Surveillance, Tracking and Imaging Program (ASTIP) demonstrator, and tested it in a series of experimental trials with propeller aircraft and helicopters. Hing Chan used the Facility to gather ground clutter data for analysis and characterization. Although still situated on the roof of Bldg. 2B, the radar was taken out of service in 1989.

Another significant research activity for the Section was the Low Angle Tracking Project, started in 1974. Previously investigated by David Mabey (during his first appearance at CRC while on exchange from the UK), the project evolved over the years to develop techniques which have surpassed the performance of all other known tracking techniques. John Litva, now at McMaster University, ran the project for a number of years. Later, Ross Turner took on this role, with assistance from Eric Hung and Eloi Bosse. Ross Fines, Len Taylor, Dave Selwyn, Jean Caseault, Eloi Bosse, Ed Riseborough and Denis Lamothe developed the experimental facilities for the project. This has included the establishment of the permanent field site at Area 5 on the Ottawa River to perform experimental validation of these new techniques, and the regular use of boats and helicopters as target emulators.

The low-angle tracking work has recently evolved once more to become the Multifunction Radar Project, which will form the basis of the Surface Radar technology-base program for the foreseeable future, and will include techniques and algorithms developed under the Adaptive Radar Project.

The Surface Radar Section has devoted considerable effort to detection and tracking techniques for maritime and ground-based surveillance radars. Gordon Marwood, Guy Painchaud, Martin Stanley-Jones, Bert Bridgewater and Martin Blanchette have all been involved in this work.

The Section also has responded to numerous DND taskings and procurement requirements over the years. Reg Cross, Mike Patriarche, Gerry Venier, Gordon Marwood, Carl Thorsteinson, Ron Martin, and Guy Painchaud, amongst others, were particularly active in this regard.

About 1980 the Radar Research Laboratory initiated work in Space-Based Radar (SBR), following the participation of David Mabey and Alan Sewards in the Joint US Canada Air Defence Study. Bert Bridgewater, Ross Turner, Ron Martin, John Bird, and Brian Rook lent their analytical, technical, and computer-simulation expertise to this endeavour. The subsequent arrival of Winston Tam and Denis Faubert led to the formation of the Target Discrimination Group, which provided some crucial analytical results on the detection of air targets from space-radar platforms. With the launching of DND's SBR Project in 1987, the Section continued to provide support to the SBR Project Office in DREO/ED, by contributing technical advice and supervising industrial contracts.

One of the newer significant activities in the Surface Radar Section is the HF Surface Wave Radar Project. This work depends primarily on contracted research, with a major part of this being undertaken in Newfoundland. Under the guidance of Tim Coyne, this has included setting up a radar site at Cape Bonavista. Although the focus of the work until recently has been on the detection of low flying targets such as sea-skimming missiles, another use of the technology is for long-range coastal surveillance, as an adjunct to air and naval surveillance of Canada's coasts, for fishery protection, drug interdiction, and sovereignty missions.

Much of the Surface Radar Section's work over the years has involved international collaborative activities, particularly in TTCP and NATO. Guy Painchaud played a significant role in the NATO Anti-Air Warfare System project; and in the same connection, Mike Noorani was seconded to the Applied Physics Laboratory near Washington for three years. Other scientist exchanges included Bert Bridgewater's one-year stay in Germany in 1984/85, and our hosting of several German and Dutch scientists between 1987 and 1990. Research on Radar Clutter, for which Hing Chan has been responsible, has also been an important activity for a number of years, benefitting from and contributing to collaborative work between Canada and the US and UK.

TECHNICAL PROGRAMS NO LONGER AT DREO

PROGRAMS ONCE PART OF THE CHEMICAL WARFARE EFFORT

by

Jim Norman

INTRODUCTION

The original mandate of CWL/DRCL had been expanded somewhat beyond the chemical-warfare program into only marginally-related fields, to take advantage of the expertise in chemistry and chemical-engineering at the Establishment, and of the facilities of the Pilot Plant for development. The areas of expansion included programs on flamethrower fuels, on fluorine chemistry, and on batteries.

THE FLAMETHROWER FUELS PROGRAM TO 1960*

This program which began in the mid-'40s lasted until 1960. It was designed to assist the Canadian Army in its armaments program, and included laboratory research, development elements, and practical-applications studies. This work was carried out by a team led by Harry Sheffer and included Adrian Léger and Ron Haines as professional staff and Colin Hyde and Bill Barnes as technical assistants. Research studies were designed to lead to improved gelling agents for fuels, to better "stickiness" of burning fuel impacting on its target, and to better stability of gelled fuel. The laboratory work included the determination of parameters that affect thickening and stability, and the elucidation of the thickening mechanism. New thickening agents were prepared and studied. Some were new aluminum soaps, others were other-metal soaps, some were organic polymers specially synthesized for this role. This work led to development of new methods of measuring molecular weights of high polymers using light-scattering techniques, and a concomitant development of a differential refractometer for this light-scattering work with a precision two orders of magnitude greater than then-existing instruments. This work also led to the elucidation of the structures of aluminium di- and tri- soaps.

Development activities, also under Harry Sheffer, added the professional and technical staff of the pilot plant: Mr. T. O'Neil, Jim Wheat, Don MacLeod, Bob Dunlop, Joe Doherty, Chuck Thompson, and Doug Scharf to the research team. One result of the R&D work was the selection of "Octal" (aluminium octoate) as the thickener of choice by the Canadian Army over aluminium stearate, the then-standard American-Army thickener. Octal was not an item of commerce at that time and ways to its manufacture were worked out in the pilot plant. The need for Octal became urgent in 1950, because of Canada's commitment of troops to UN Forces during the Korean Police Action. Ultimately, all the Octal used was manufactured in the Pilot Plant, which went on a war footing, working 3 shifts per day, 7 days per week for 2 years, to keep the military supplied. After the Korean conflict, the technology for Octal manufacture was transferred to Industry, and these pilot-plant manufacturing activities ceased.

An enormous number of practical-applications studies were carried out by DREO staff using the immediately-adjacent portions of the site on an ad hoc basis. Trial batches of thickened fuels were prepared, tested, stored, retested (and this cycle repeated many times over) by the research staff in the quest for the optimum thickened fuel for flamethrowers. The main criteria were ease of thickening of fuel, range attainable, and storage stability. Similarly, the flamethrowers themselves were modified, tested, redesigned, etc., many times over to develop the ideal flamethrower to use the optimum fuel.

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* Based on a write-up by Ron Haines.

More formal trials of the modified fuels and flamethrowers were conducted at the test ranges at Suffield by a small group of flamethrower specialists from the Army. Trials of DREO-developed thickened fuels using large vehicle-mounted mechanized flamethrowers also were conducted by this group at Suffield.

In late 1960, the Canadian Army adopted the US Army's flamethrower, in spite of it being inferior to the Canadian armament, and the flamethrower-fuel R&D program was terminated.

THE FLUORINE-CHEMISTRY PROGRAM TO 1957

Fluorine chemistry became a major portion of the wartime chemical-warfare program as wartime research generated a need for this halogen to support the work on the many gaseous, highly-toxic mono- and di-sulphur polyfluorides thought to be potential war gases. Disulphur decafluoride S_2F_{10} was the main sulphur compound studied, and its synthesis required elemental fluorine. At first, using equipment borrowed from McGill University, about 20 lbs of fluorine was prepared. The corrosive natures of the starting materials for synthesis and of the highly-reactive fluorine itself were major problems requiring solution before fluorine in a pure (relatively) state could be obtained. This early work also revealed the magnitude of the problems to be expected for preparation of fluorine on a much larger scale.

Means of reacting sulphur and fluorine to produce the desired S_2F_{10} (and not the much more common SF_6) required extensive R&D and led to investigations of mixed halides such as fluorine trichloride and tribromide. Investigation of these latter materials showed their extremely high oxidation potentials and their extremely high rates of reaction with almost all organic materials -- indeed, a few drops of these materials placed on any organic surface (for example, the desk top, the hands, the face, clothing, shoes, the floor) caused that surface to burst into flames and also to produce a dense, acrid white smoke. These properties aroused interest in their use as incendiaries and as sources of screening smokes but the practical problems of safe containment (these reactive liquids ate through almost all containers, even those of glass) were never solved.

Later, special all-copper apparatus was built at CWL and a very large quantity of fluorine, about 200 lb, was produced, sufficient to support the S_2F_{10} work and all the other fluorine-chemistry investigations of those days.

Post-war technical intelligence teams furnished the western allies with samples of CW agents* which had been prepared and stockpiled by Germany. These were found to be of two classes unknown to the Allies and both contained fluorine. One class, the G agents, was found to be phosphonofluoridates (or close relatives) and were supertoxic, one to two orders of magnitude more toxic than any previously-known war gas. The other class, the monofluoro-acetates, while not supertoxic, did not appear to break down. They were not detoxified in the body and did not appear to hydrolyse in water nor in strong acids or bases. These generated a round of research to discover how to incorporate fluorine into phosphorus molecule and how to generate the various oxidation states of phosphorus molecules containing fluorine, and how to incorporate fluorine into an organic molecule. Eventually, it was found that the required starting materials for phosphonofluoridates were mixtures of phosphorus trichloride, PCl_3 and trifluoride, PF_3, or of phosphorus oxychloride $POCl_3$ and oxyfluoride, POF_3, satisfactory methods for preparing these (or similar) starting materials were worked out.

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* The USSR did even better. They discovered the plant making these agents and had it disassembled and transported, along with all its staff, to mid-Russia where it was reassembled and put back into operation. The plant continued to operate for the next 36 years, manufacturing agents for the Soviets.

Incorporation of fluorine into an organic molecule was simpler, simple nucleophilic substitution was effective, provided all the reagents were superdry. Trace quantities of water prevented fluorine substitution.

With this information on hand, the program moved on, concentrating on preparing a large number of phosphonofluoridates for studies of toxicities, reactivities, utilities on the battlefield, etc. to evaluate the potentials of G agents as CW agents, and similar studies leading to an evaluation of monofluoroacetates as war gases. The fluorine-chemistry program then was terminated in 1957.

Over the years, the staff associated with the fluorine program included Jack Dacey, Miles Benson, Jimmy Dale, Gerry O'Neil, Dave English, Ernie Criddle, and Leo Carisse.

THE GENERAL CHEMISTRY PROGRAM - TO 1961

This program was short lived. It included the batteries research program but this was split off in the first year to become, eventually the Energy Conversion Division (see the write-up by Ernie Criddle). The balance of this program was to provide high-tech (for the time) services. These included a UV-VIS-IR spectrophotometry laboratory and electromagnetic proton resonance spectroscopy facility. Other services, for example the organic microanalysis laboratory, were operated by the Chemical Warfare Section. When the General Chemistry program collapsed the following year, its Services Laboratories and other specialized facilities were absorbed by the Chemical Warfare Section.

The General Chemistry program was headed up, temporarily by Harry Sheffer, and then by Charlie Hubley. Other staff included Art Grey, Yvon Marois, Bob McIvor, Cathy Scissons, for the optical spectroscopy lab and Marcus Weinberger, Tom Mousseau, and Pat Lutley in the electromagnetic resonance spectroscopy facility.

THE BIOLOGICAL DEFENCE PROGRAM - TO 1969

by

Jim Norman

INTRODUCTION

This program, like the chemical defence program, had its origins in wartime research. It operated out of two facilities, the "Kingston Laboratory" at Queen's University and the field station, Grosse Ile Experimental Station (GIES), which was an isolated island in the middle of the St. Lawrence River about 15 miles downriver from Québec.

The exact programs of these two Establishments are still not known precisely, however a reasonably accurate and detailed account of much of their work has been presented in the recently published book "Deadly Allies" by John Bryden*. His account indicates the program to have been wide-ranging and to have investigated most of the parameters important to BW, including studies of those microorganisms likely to be BW agents. One of the major accomplishments of the wartime BW R&D program was the development of an effective vaccine for rinderpest, a disease of cattle then unknown in North America, characterized by a near-100% fatality rate. Peacetime application of this wartime research has made it possible to virtually eliminate this disease worldwide. Indeed, it was stated that "this discovery alone would contribute enough to the food supply of a starving world to justify the whole of Canada's expenditure on research"**.

GIES was closed at the end of WWII, its research program being absorbed into that of the Kingston Lab which, in the late '40s and early '50s was renamed the Defence Research Kingston Laboratory (DRKL) and relocated to DND land on Camp Barriefield (now CFB Kingston).

DRKL's programs were biology based and, in addition to the peacetime biological defence program, also included the programs on CW agent toxicology, on prophylaxis and therapy, and on radiation biology. In 1956, it was decided to close the smaller DRKL Establishment and amalgamate its programs into the much larger DRCL. In 1959, new construction began at Shirleys Bay to accommodate these programs. As facilities were completed, the programs, equipment, and personnel were transferred to DRCL. The CW agent toxicity, prophylaxis and therapy, and radiation biology programs were the first transferred. Facilities for the Biological Defence program were complicated and their proper operations was essential to safety. Its transfer was delayed until operation of all containment systems had been tested and made to meet specifications. The program transferred in 1964 and the facilities at DRKL were de-commissioned.

The BW program transferred was a mature program with a long history of success -- but it lasted at DREO for only five years until, in 1969, it was transferred again, to DRES and merged with the similar program at that Establishment.

During its short time at DREO, it continued its projects of its original mandate, conducting R&D in five main study areas:

dissemination and collection of airborne biological material;

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* John Bryden "Deadly Allies" McClelland and Steward Inc., 481 University Ave., Toronto, Ontario (1989). ISBN 0-7710-1724-3.

** Dr. O.M. Solandt, the then-newly-appointed Chairman of the newly-created Defence Research Board, in a Radio Address, January 1947.

- detection and early warning of biological attack;
- identification of BW agents;
- immunizations and vaccine development;
- infectivity studies.

The program also included more general-purpose activities, for example, effectiveness of new decontaminants, evaluation of new materials for swabs, and similar work, and some developments for the military, for example, SOPs for decontamination, unmasking drills, disrobing procedures, and development of small kits for sampling for BW agents; and development of containers for safe transport of dangerous biologically-active material.

DISSEMINATION AND COLLECTION STUDIES

Dissemination studies looked at many of the factors important for making a practical BW agent. These included studies of growth media, nutrient materials, harvesting techniques, etc., important to supplying the raw agent material; and also looked into preparation of the aerosol itself, and the use of stabilizing colloids, nutrient materials, protective coatings, etc. Studies also investigated the effects of the real world upon disseminated material, to assess loss of virulence from natural-exposure factors such as sunlight, UV light, heat, humidity, temperature and temperature change, windspeed, rain, fog, etc.

Collection studies investigated various means of sampling BW agent clouds, and how airborne agent might be sorted out from innocuous background airborne material. This involved non-specific collection techniques to collect all biologically-active airborne materials, and specific collection techniques such as cascade impaction which sorts airborne aerosols by size, charged-rod sampling which sorts by particle charge, and by many other collection techniques claimed to be highly specific for agents.

Both dissemination and collection studies were concerned with physical parameters of aerosols and many studies were undertaken to determine particle size and size ranges, particle concentrations, fallout rates (and effects of micrometeorology on such rates) accretion rates, re-suspension, impaction and collection efficiencies of a wide variety of target surfaces, clothing penetrations in still and moving air, and similar topics.

All of these studies contributed to the capabilities to assess materials as possible BW agents, and provided insight into effectiveness, down-range travel, area coverage, all matters relating to devising defences against BW agent use.

DETECTION AND EARLY WARNING

This work looked for ways to provide early warning of BW agent attack and means to identify the attacking agent. One study involved detection of BW agent in collected airborne protein material. While proteinaceous material could be detected, aerosolized BW agent could not be distinguished from the very large background airborne protein from dust pollens, normal non-pathogenic bacteria, viruses, etc. Fractionation of airborne protein material through use of a cascade impactor did not improve BW agent detection over background. Later studies looked at the development of a hand-operated detection kit for BW agents. This borrowed several concepts from the C2 Chemical Agent Detector Kit also under development at that time. Prototypes of this BW Detector Kit were fabricated, but never taken further.

One approach to sampling airborne microorganisms was to have the man act as his own sampler by putting a plug of aerosol-filter material at the air inlet of the mask canister. As he breathed, he then automatically sampled the air. Unfortunately, conventional techniques were not fast enough for detection or early-warning purposes. The procedure was found useful however for assessing NBC protective mask performance. The method was made quantitative for BW agent concentration in air. By installing a second filter plug in the nosecup opening, concentrations of agent in-mask could be determined and, from the interior and exterior agent concentrations, mask efficiencies could be calculated. These studies allowed such assessments to be correlated with soldier activities, for example, movements related to covering open ground, preparing a defensive position, etc.

A second approach to detection was to follow uptake of ^{32}P by collected BW agents but this too was unsuccessful from the point of view of detection. The technique was found to be non-specific, however it was found to be useful for uptake-mechanism studies.

Another approach studied during the time at DREO was to look at phosphorescence techniques. This study was taken to DRES and became part of studies of methods of identifying BW agents.

IDENTIFICATION OF BW AGENTS

A major problem always has been to identify unequivocally, a BW agent sample. Approaches in the '60s included: fluorescent antibody techniques, bacteriophage typing, culture growth enhancements, and immunoelectrophoresis. Studies also looked at influences of the collection media on these factors. One specific study related to new viral antibodies and characterization of an Influenza Type A virus.

IMMUNIZATIONS AND VACCINE DEVELOPMENT

Studies on these subjects included development of an immunization and vaccine against Glanders.

INFECTIVITY STUDIES

One study looked at the combined effects of radiation and viral infection. It was found that these two factors were, for all practical purposes, independent, until radiation dosages reached the one LD_{50} level.

Other infectivity studies looked at BW agent aerosol ageing and loss of infectivity, viability, etc. Most of these studies were conducted in the rotating drum facility at DREO. Larger scale trials were conducted in the shed facility at DRES. The work did study the effects of exposure to very low doses of agent for very long times in animals for comparison with high-dose, short-time exposure trials.

All of these studies terminated in early 1969. The special equipment, BW agent stocks, etc. were moved to DRES in that year and Building 5C was disinfected and decommissioned.

THE PEOPLE

The people involved in this program were: Jack Currie as Head of Section; and staff: Dorothy Evans, Aggie Frazer, Doug Kennedy, Jack Konawalchuk, Al Laing, Phil Little, Bev Magill, Nancy Malekoff, Bud O'Connell, Geo. Patten, Kathleen Patterson (Shaw), Gar Pike, Jean Speirs, Bill Thompson, and Lloyd White.

ENERGY CONVERSION DIVISION - TO 1986

by

Ernie Criddle

In 1950 the Defence Research Board hired Dr. E.J. (Jerry) Casey to initiate their Battery Group at the Defence Research Chemical Laboratories. Over its lifetime, the Group swelled to a Division of 35 scientists and support staff, and included a Vehicle Mobility Group and a Fuels/Combustion Section. The Division was closed at DREO in 1985 and the responsibility for the residual research programs needed was transferred to CRAD Headquarters.

The first tasks tackled by the new group on batteries R&D included a broad spectrum of activities: technical consulting, system studies, research, development, and engineering. The research programs also demanded a broad awareness of needs and developments in universities, industries, and in other government departments. The need for a mutual awareness often spawned an advisory committee on power sources which took several titles and organizational structures over the years, and the Group grew into a Section.

In its heyday, the Battery Section played a pivotal role in international battery developments. For example, staff members invented a process to prepare nickel electrodes for nickel cadmium NiCd batteries in the 1950's which is still used today. Their further engineering of NiCd batteries provided a long-life space battery which was used by a number of Canadian satellites, beginning with the first, Alouette I. At the time of launch in 1962, the previous record for life of NiCd batteries in space was 30 days. The batteries in Alouette I exceeded this record immensely: its batteries were still operational 25 years later. To accomplish this outstanding feat, the team studied failure modes most intensely. The results were used by the manufacturer to make improvements to the electrodes, electrolyte, separator, and cell-case seal. These improvements also entered the civilian market to produce reliably-rechargeable NiCd batteries which are now available everywhere.

Other inventions and design improvements originated in this Division. Expensive silver chloride in torpedo batteries was replaced by cheap lead chloride. Inexpensive air electrodes were invented for use in metal-air cells; zinc electrodes were also improved for this application. A pure-water preparation system was invented which is still used in modified form in electrochemical research laboratories. Battery packs to be powered by wind generators or solar panels were engineered for remote locations. The Section grew to become the Power Sources Division.

Little wonder that this Division was also called on to overcome many of DNDs application problems. These included lead-acid batteries for vehicles, lithium- and other cells in radio packs, fuse batteries for munitions, and the promise of fuel cells for efficient energy conversion.

The know-how behind these years of consultation came from a program of research which looked at changing technologies, failure analyses, and user problems especially in extreme environments: the effects of cold, heat, vacuum or high pressure on battery systems; the fundamental processes viewed with a rotating ring electrode; dendrite growth on zinc and silver electrodes; forced over-discharging of lithium cells; and other considerations in the real world of electrochemistry. Instrumentation used to study battery problems included NMR, IR, Laser-Raman, and cyclic voltammetry.

As the needs of DND and the military user changed, so did the DRB/CRAD Organization and the role, function, organization of the DRB Establishments also changed. For example, the demise of DRTE caused the relocation of some of its elements to DREO to become the Earth Sciences Division. In turn, its demise transferred the Vehicle Mobility program to the Power Sources Division. This sparked a new interest in fuels use, combustion technology, etc. The demands of the changing technologies moved part of the staff into new R&D areas and the Division took on added responsibilities. New staff was added and the name of the Division was changed to reflect its new responsibilities and it became the Energy Conversion Division.

Again, changing technologies and changing military priorities affected the Division; this time, fatally. The electrochemistry and batteries research was phased out and a small technically-expert group was placed at University of Ottawa to look after the residual needs of the military. Similarly, Fuels/Combustion work was transferred to NRC to their Engines Laboratory, and the Division was closed. The last Director of this Division was W.A. "Bill" Armstrong who acted in this position for four years while Jerry Casey was on extended sick leave. He then moved on to become DREO's Deputy Chief, and then to CRAD HQ, to be Acting DGRD Ops at CRAD HQ until his retirement.

Editor's Note

No account of the Division can be written without paying tribute to Jerry Casey who guided the original Battery Group through all its changes on the road to becoming a Division, and who provided much of the impetus and expertise to its technical program. Jerry's influence lasted long after the unfortunate accident that robbed us of the last six years of his life. All who knew him regret his final years.

THE EARTH SCIENCES DIVISION - TO 1974

by

Jay Greenblatt

The close of the 1960's saw a growth in and a refocussing of the Canadian Forces interest in arctic Canada. This was a result of: the transit of the US tanker Manhattan through the North-West Passage and the questions that event raised about Canada's sovereignty; the acquisition of submarine-launched ballistic missiles by the Soviets and the realization that the heartland of the US and southern Canada could be threatened by these systems from "stand off" positions under the frozen ice cover; the beginning of the search for oil in the Arctic and the necessity to exercise Canadian control of the activity and traffic; and finally, the acceptance of search-and-rescue responsibility in support of the increasing trans-polar jet flights. The DND focus on northern and arctic Canada was met by response from DRB in support of DND's missions in that region of Canada, which was broadly based and had elements located in the various DRB laboratories. The main program elements located at DREO dealt with the arctic environment, specifically ice, air and sea interactions; the properties of arctic terrain and the effect of these when conducting operations over such terrain; and the use of remote-sensing techniques for obtaining physical and geophysical information and intelligence data. DREO was also tasked with coordinating all the arctic oriented programs of DRB.

In 1969, a small nucleus of arctic experts, scientific personnel, were established at DREO as the Geophysics Section. In 1970, a Remote Sensing Section was added to augment the Geophysics Section. This last then became the Ice Research Section. Both of these made up the Earth Sciences Division which came into existence in 1970.

MISSION

The mission of the Earth Sciences Division was:

(1) To determine the water current in arctic channels identified as constituting the main points of entrance and egress into the Canadian Arctic under both fast ice and broken moving ice;

(2) To determine the rate of movement of arctic ice in the so-called choke-point channels and to identify the driving forces (wind and water current) that caused the movement;

(3) To use the above information to draw conclusions on how arctic conditions would affect system installation and operation, and movement through arctic waters;

(4) To evaluate available airborne remote-sensing systems such as infrared line scanners (IRLS) and forward-looking infrared (FLIR), sideways-looking airborne radar (SLAR), and later, synthetic-aperture radar (SAR), as well as satellite infrared imagery. This was to be done by mounting ground-truthing exercises in conjunction with sensor overflights;

(5) To evaluate the use of operational radar systems to get ice information, particularly in the dark period. Again, this would be done by ground truthing the areas overflown;

(6) To evaluate terrain properties by SLAR & IRLS. This was supported by ground truthing with a view to developing a data base of terrain properties for a number of representative northern areas that could be applied to analogous terrain of operational interest in other areas and at any given time;

(7) To investigate mobility over various types of arctic terrain and to evaluate possible vehicles that could be used operationally;

(8) To coordinate all the Arctic oriented research and investigations across the spectrum of DRB laboratories and to keep the Board's senior management apprised of the progress of the overall effort and its responsiveness to Canadian Forces requirements.

ACHIEVEMENTS

The Geophysics section, prior to its incorporation into the Earth Sciences Division as the Ice Research Section, had taken part in a number of overflights of Robeson Channel where data on the appearance of the ice cover was obtained by eyeball, camera, and with radar. The information was collated and published as a descriptive summary of the ice regime through the year. Of particular interest was the "North Water" phenomenon. This was an arch of open water or of very thin ice of varying extent from year to year forming just below Kane Basin. This area was also visited on the ground to give required ground truth and a few years later the division continued such work and gave logistic, funding and other support to McGill scientists studying the energy transfer at the North Water. From the data they gathered they postulated the transfer involved initial evaporation from the open water, followed by precipitation in the form of snow on adjacent high ground from where, after accumulation, compaction, and being turned into ice, it was extruded back into the water.

Prior to beginning work in Robeson Channel on ice movement, the Geophysics/Ice Research Section rounded off a number of geographical and geophysical reconnaissances they had done or were doing from a base established at Lake Hazen on Ellesmere Island. The work dealt with: the ice cover on many of the sounds and fiords of northern Ellesmere Island; the Ward Hunt Ice Shelf; and the variation in the height of the altitude limit for permanent ice and the amount of ablation or accumulation of snow at selected ice caps. The Ward-Hunt data confirmed the shelf as the source of ice islands formed by break-off of large pieces of the shelf. The extent of the permanent snow cover and two small ice caps on Ellesmere Island as measured by ablative stakes and comparison with previously taken aerial photographs suggested a warming trend from 1959 to 1972 (the date of reporting) which could be accounted for by a warmer summer temperature.

A large scale ice-movement experiment was planned for Robeson Channel. The plan was to measure currents under the fast ice by emplacing strings of current meters through the ice across Robeson Channel and leaving them emplaced until just before break-up. After break-up, ice movement would be followed by tracking suitable radar emitters set out on selected ice floes. The signal was received by a small radar mounted on top of a hut atop the edge of the cliff rising from Robeson Channel. The radar range was 20 miles. Wind data was obtained from anemometers also set out on the ice floes. The instruments were carried to the ice floes and retrieved from them using a helicopter. After selection of a suitable work site in 1970 and the establishment of a work station in 1971, attempts were made to measure ice movement using metallic corner reflectors as the emitters on the ice. These were unsuccessful -- the noise from returns from the rough ice surface swamped the weak signal from the corner reflectors.

In 1972, radar transponders were used as the emitting source on the floes and good tracking was achieved. Simultaneous wind and ice-drift data were obtained. Water current data through the fast ice had been obtained earlier in the year using this system.

When the data was processed, it was evident that tidal current was the main and constant force acting on the ice. Ice moved in both north and south directions but with a predominant southerly direction, i.e. the southern flow time was longer than the northern so that an instrumented floe finally moved out of range by going south. Wind when strong enough was an overriding force. Ice moved north continually, against the current in one case because of a storm. When wind and current acted in unison, ice movement was rapid and when in opposition it was slower. The water current was found to be 1 – 2 knots per hour.

The movement of the ice was also followed by photographing the channel below the observation site at fixed time intervals, and later by an optical system which displayed a real-time image on a T.V. screen and compared it to a stored image of the same floe taken earlier. With this system, the progress of a number of floes could be followed almost simultaneously. An advantage of the technique was that a standby helicopter was not required for retrieving and repositioning beacons. Also, smaller floes could be followed. The radar technique was limited to floes large enough to support safely the landing and take-off of a large helicopter. The main disadvantage was the much shorter range of the optical system.

The totality of data obtained in Robeson Channel allowed the definition of the ice regime in the channel and led to observations on how acoustic surveillance systems might be effected. For example, noise should peak at the time flow-direction changed because the maximum number of inter-floe collisions occur at this time. Since these turnarounds are diurnul and tide related, they could be predicted easily.

In 1973 and 1974, a more intensive water-current, water-temperature survey was made across Robeson Channel using a larger number of current meters. The data from this work allowed a better model of the water and heat transport down the Channel to be set up.

Subsequent surveys similar to those in Robeson Channel were made in a number of other "choke-point" channels. One of these had an ice regime at a constriction similar to the North Water phenomena. It was found that ice movement in the various Arctic channels was based on the same water-current, wind interactions as in Robeson Channel.

At the start of the remote-sensing program, a number of ground-truthing exercises were done in support of overflights by aircraft using SLAR and IRLS. These were all made in southern Canada, but since there were no DND aircraft mounting these sensors, arrangements were made with U.S. Defence Agencies and with other Canadian Departments for the overflights. From its inception, the work had considerable interaction with the National and International remote-sensing community. Opportunity was also taken of the availability of satellite IR imagery from the read-out station at Prince Albert, Saskatchewan and this was integrated into the general evaluation and ground-truthing exercises, particularly as it affected the evaluation of terrain.

A number of contracts were negotiated with staff at McGill University, the University of British Columbia, and other Universities who were working in the field of interpreting remotely-sensed imagery and were constructing useable maps on both macro and micro scales. This latter involved the work of geographers at McGill University using aerial photography taken at Camps Gagetown and Petawawa, and using techniques developed earlier.

For surveillance and intelligence gathering, information had to be obtained in real time. With the IRLS and SLAR systems in use at the beginning of the program, most of the data was processed when the aircraft carrying the system returned to base. One quick look at parts of the IR data could be obtained by on-board photographic processing. This was unsatisfactory and the Remote-Sensing Section began the development of a real-time analogue processor which used a cylindrical lens as the central part of the processor. The lens itself was manufactured through an industrial contract. Although conceived originally as a possibility for either SLAR or IRLS, it became identified with the synthetic aperture radar being developed in Canada. A prototype was built but it did not match the performance capability of system being developed in the Defence Electronics Division at DREO, and after 1976 when the Remote-Sensing Section became part of that division, the analogue approach was dropped and a digital processor was produced in conjunction with MacDonald-Detweiler of Vancouver. This processor was very effective and turned out to be very successful.

In parallel with the ground-truthing trials, a laboratory investigation of the IR spectra of typical background and target material was made using a Fourier-transform spectrophotometer in the reflection mode. The instrument was mounted in the laboratory and looked out through an IR-transparent window to the material under evaluation remotely mounted in a special hut at a distance from the instrument. Measurements were made at various ambient temperatures and various conditions summer and winter of the transmission path. The purpose was to characterize and develop a library of spectra for the various target materials, against background, so that when a return from such material occurred on an operational flight, the system would flag the operating personnel who would redirect the aircraft to a more intensive search of the area from which the flagging radiation had come. Data on rocks, metals, paints, cloth, dyed cloth, etc. was collected. Spectral properties were found to be characteristic of the intrinsic material e.g. dyed and undyed cotton cloth had almost the same spectra.

Part of the work on terrain evaluation has already been described as an exploitation of remotely-sensed data. The other part of the work involved soil-wheel and soil-track interaction and it was done under contract at the Soils Engineering Laboratory at McGill University. Designs for more efficient tracks and tires resulted.

The mobility work was looked after by a geotechnical group, added to the Division shortly after its formation. The Geotechnical Group also had responsibility for entomology. The head of the group, Ian Lindsay, in his previous position at DRB HQ had supplied the total DRB effort in this field, 1/2 person year, and the feeling was that the problem of biting insects in the North was an important factor impacting on troop comfort and operations there, hence entomology, logically became part of the Earth Sciences Division's program.

The then-current methods of insect control using insecticides were being scrutinized, as were techniques of spraying and equipment used in southern Canada. Information and guidance were required by Canadian Forces for application to operations and bases in southern Canada, and possible future operations and bases in northern and arctic Canada. The work was done by contract. It included esoteric studies of chemical hormones that would produce sterile adults from treated larvae to more mundane trials of new designs of nozzles to cut down overspray of insecticides. Liaison with US defense entomologists was maintained to provide another source of information.

The task of coordinating all the arctic oriented work underway in the various DRB laboratories was handled by holding a series of annual reviews at which staff from different laboratories, and at times contractors, could present an account of what they were doing, what the purpose of their work was, what progress they were making and what difficulties they were experiencing. The venue of this review was moved from place to place and reviews were held at DREO, Yellowknife (Northern Region Headquarters) and Halifax. The Division also maintained liaison with US laboratories with Arctic programs, as well as other Canadian Departments, and the Oil Industry, with interests in the Arctic. These last were active in developing information on mobility and terrain properties.

After five years of existence, the Earth Sciences Division found a changed set of circumstances. Just prior to this, a major reorganization of defence science had occurred resulting in the separation of the laboratories from DRB and their being placed under a Chief Research and Development in a line function in DND.

At the same time, DND interest in the Arctic was lessening. Priorities were shifting to other areas of military technology seen as having a higher priority, for example, electronic warfare. Following in the redefinition of programs, and reallocation and regrouping of resources, the Earth Sciences Division was phased out and its elements relocated. The Remote Sensing Section, somewhat diminished, became part of an augmented Defence Electronics Division and the Ice Research Section, again somewhat diminished, was moved to DREP in support of the arctic under-water surveillance work at that laboratory. The Entomology Group became part of the Protective Sciences Division.

EPILOGUE

Later events proved the value of the long slogging hours accumulating and processing terrain data by the Earth Sciences Division. Sometime after the demise of the Division, the US Air Force wished to test and evaluate the sensors in their smart weapons. They were looking for an area, analogous in terrain and ground cover to the North German Plain, that had been extensively ground truthed and for which micro-terrain feature maps existed, and over which military formations moved in battalion and up-to-brigade size. Camp Gagetown was the obvious answer, it had been so surveyed by the Division and was a good analog of parts of North Germany. The USAF applied to Canada through channels and obtained permission to fly aircraft equipped with the sensor part only of the weapons and recording equipment. All went well until Senator Mitchell of Maine heard about the exercise and he raised questions as well as many other things. It appears that USAF had closed a base in Maine and was now going across the border to do its development work. However, none of the US bases of comparable type had been ground truthed and mapped so his objections proved fruitless and the US Air Force continued their work in Canada until they had achieved all their goals.

ADMINISTRATIVE AND SUPPORT SERVICES

INTRODUCTION

by

Jim Norman and Rita Crow

The intent of this part of the history, originally, was to provide details of DREO's administration. At present, it is diffuse; many of the original functions of the earlier administrative divisions of DREO have been transferred elsewhere, for example, to DND's Civilian Personnel Office, and to the new PSTL Division.

To give a complete picture, write-ups of all the elements providing support:

- The Administration Division;
- Program Support Telecommunications Liaison;
- Civilian Personnel Office;

are collected below.

Security, health, and safety, strictly speaking, are not direct responsibilities of Administration, however, they cut across all divisions and lines of the Establishment and affect everyone. Responsibilities to oversee such matters have been assigned to individuals or to committees by the Chief, for the whole Establishment. Therefore, we have chosen to include them here in this section dealing with administration and support.

THE ADMINISTRATION DIVISION

by

Jim Norman

DREO in its early manifestations (CWL and DRCL) had little formal structure. There was an Administrative Officer (Major Mason, then Walter McLintock), looking after Supply (Ken Haley), Finance (Miss Osborne), Personnel (Lena Carmody), and the Records Office (Mrs. McDermot), the Librarian (Betty Lang); and the Heads of the various scientific or technical Sections. All reported directly to the Officer-in-Charge of the Laboratory; at first, the Superintendent, (Jack Dacey, Jack Arnell, Harry Sheffer), later, the Chief Superintendent (Harry Sheffer). In a very real sense, all employees worked for the Superintendent and he personally oversaw all the scientific and technical work and much of the administrative work as well. Finance looked after travel and aspects of personnel and pay; Supply looked after procurement, stores, inventory, and the drivers. Oscar Chambers was the Administrative Officer at DRKL (the Kingston Labs) and when DRCL and DRKL were amalgamated at Shirleys Bay, Oscar moved to DRCL to become Head of Finance.

When Administration became a Division, Ken Gibson became its first Director. Other Directors who followed were Don Blakeley, Roger Desjardins, Oscar Chambers, and now Janis Pelletier.

There has very little turnover in the positions of Head of Finance or Supply. Miss T. Osborne was Head of Finance from 1952 to 1962 when Oscar Chambers took over. The third H/Finance in DREO's history is Milt Isaacs, who arrived in 1984 when Oscar moved up to become D/Admin.

Similarly, there have been only 3 Heads of Supply. First was Ken Haley who headed up Supply from DREO's beginnings until his retirement in 1983. Ken had been the sergeant in charge of the Chemical Warfare Labs' supply office during wartime and had the honour of being the first employee to be taken on by the first Chairman of the newly-created DRB, Dr. O.M. Solandt. Ken also was one of the all-time champion scroungers and fixers that DRB and DREO had every encountered. André Chartrand took over from Ken, followed by Ken Fife in 1988.* Eddie Doyle and Irene Wagner have looked after Inventory Control, Rita (McKenna) Bury and Fred Flynn have managed Procurement, John Carnie, Henri Marleau, Gerry Richer, Lauren Lepine, Al Benoit and Pete Henry have tended to Stores. DREO drivers were attached to the Stores and included Merv Lynch, Jack Lightle, Gale Crawford and Sam Cole before responsibility for transportation went to CFB Ottawa.

In the first year at Shirleys Bay, the Administrative Officer and his staff occupied space in the basement of Bldg 5A but then moved to Bldg 4, occupying space now occupied by PSD's Engineering Development Group. Walter McLintock and Ken Haley occupied two of the offices, Lena Carmody and Miss Osborne occupied the third. The large outer floorspace accommodated the clerks and secretaries, the inventory officer, and Central Registry. In the mid-'70s these groups returned to Bldg 5A, occupying the space on the 1st floor now used by Publications, TLO, and Computer Services. In 1988, these offices relocated to the newly renovated Bldg 6, following the transfer of the machine shop to Bldg 5C.

Stores, Shipping and Receiving, and the Transportation Group (when it was at DREO) first occupied Rm 8 in Bldg 5A -- indeed, the original loading dock can still be seen. These groups then transferred to Bldg 5C (Rms 36, 38, space now occupied by the photographer) and then into Bldg 29, which is its present location. At various times, Shipping and Receiving and Stores have interchanged their locations within Bldg 29, have shared their space with some animal keeping facilities, with the photographer, and, most recently, with the electronically shielded room.

Central Registry was part of Administration until 1979 when it was attached to the office of the Chief, and brought under the Library. In 1984, it reverted to Administration. In 1988, it was transferred again returning to Program Support Division. Mrs. McDermot, Mrs. Moodie, Anne Desjardins, and Nancy Olive have been the managers of the Central Registry.

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* Ken Fife retired in very late 1991 and, presently, the position is vacant.

The Personnel Office was run by DRB in the Daly Annex and later, at DRB's building at 190 O'Connor Street, with attendance, pay and benefits delegated to the labs (at DREO, Lena Carmody). When DREO became part of DND on 1 April 1974, personnel functions were transferred to DND personnel offices and this ceased to be a DREO responsibility.

In 1989, a major effort to modernize, to update and replace older hand-operated systems with newer computer-based systems, culminated with the records office and finance, procurement, supply, and inventory-control being automated: the records office added an automated file-retrieval system and listed all incoming correspondence etc. (previously manually handled) into a computer for easy dissemination, retrieval, etc. At the same time an integrated, computerized procurement system involving requisition, procurement authorization, financial coding, ordering procedures, receiving, and inventorying was established. Finance, now also computerized, utilized this information, adding it to its Capital- and O&M-commitments-and contracts-letting-data bases, to produce the Establishment's Financial Information System. Similarly, Inventory Control replaced the original hand written/typed inventories with computerized versions based on asset numbers and machine-readable identification plaques on all equipment.

Such a heavy automation resulted in the formation of a Computer Services Section, under Mark Gill, in the Administration Division. As well as the automated functions mentioned above, Mark generally oversaw the introduction of computer-based word processors into the offices of the Establishment and acquisition of the appropriate data bases and Operating Programs. The application of computers, data bases, etc. to the scientific R&D programs had begun much earlier, driven by the research needs of the individual scientists and the Computer Services Section was not involved in these computer acquisitions. Much later, Mark's expertise was tapped by many scientists to aid in selecting instrumentation appropriate to each of the research programs.

Management of DREO's minor construction had been assigned to H/Supply and Ken Haley, with his vast "old-boy" network, was able to keep a close eye on this activity. When André Chartrand took over as H/Supply, DREO had embarked on a major renovation plan and the work involved became too much for a busy Head of Supply (and acting D/Admin) to handle on a part-time basis. This function was split-off from H/Supply and handled by hiring a construction supervisor for DREO on a term basis. The first supervisor was Bob Cressman, the next was Joan Ross.

With creation of the new Program Support Telecommunications Liaison Division, realignments were made in late 1990. Groups whose functions related to procurement and supply; finance, ordering, supply, inventory control, stores, shipping and receiving, etc., remained with D/Admin. Those groups providing support services were assigned to D/PSTL. These included the Library, Publications (including Photographics and Illustrations) and TLO, and added Construction and Computer Services from Administration and the Machine/Model Shop from PSD. In a counter move, the Training and Conference-Room Coordination was transferred from PSTL to Admin.

PROGRAM SUPPORT TELECOMMUNICATIONS LIAISON DIVISION

by

Various Authors

INTRODUCTION - by Jim Norman

Program Support Telecommunications Liaison (PSTL) Division is new, being formed in 1989 under Ross Abercrombie (acting) and now being headed by Bill Osborne. It had three distinct roots within the previous organization. The first includes the oldest support elements of the Establishment, originating as elements directly under the Superintendent of the Laboratories (the current position equivalent is that of the Chief) and evolving through the first "Office of the Chief", then named the "Office of Scientific Staff Duties". These included the Library, Photography, and that office. The second root includes newer elements relating to TLO, Defence Electronics, and the Office of the Deputy Chief. The third root involves elements transferred, for example: Printing and Publishing originally was a function of the DREO Library. The Illustrations Group was a function of DREO's Drafting Office, an element of the Engineering Section, first in D Wing, then in PSD. Similarly, the Machine and Model Shop also was an Engineering Section element within PSD. Construction used to be a function of H/Supply and the Computer Services Section originated within the Administration Division.

Jim Norman has written an account of the older elements and how they evolved into PSTL Sections, while LeRoy Nelms, Bill Osborne, and Joan Ross have written of the newer elements.

EVOLUTION FROM THE SUPERINTENDENT'S OFFICE - by Jim Norman

The Library

The Library is one of the oldest elements of DREO. It was formed in the early '40s as part of CWL and it was headed by Capt E.A. (Betty) Lang. At war's end, Betty joined DRB and continued to head DREO's Library until her retirement in 1975. Betty returned to University in these early peacetime years, part time, to finish her degree in Library Science, in 1964. She married in 1973, becoming Mrs. Betty Greene. When DRKL was amalgamated with DRCL, Gwen Dawson, DRKL's Librarian transferred to DRCL and became the Assistant Librarian, with special responsibility for DRCL's Books and Periodicals Collection. When Betty retired, she was not replaced immediately. Della Hackie joined DREO as librarian about one year after. Ill health forced her to leave shortly after to be replaced by Tina Matiisen. After Tina left, Susan McIntyre from DSIS, the current Librarian, took over the Library - now known as "Information Services". Susan too has been moving us into the 21st century for information handling. Most of the library functions are now automated and most information data bases can be accessed "on line".

Other library staff, over the years, have been: Chrissie Hall, Ellen Blain, Dorothy Mentzel, Nancy Saunderson, Nancy Webb, Bev Payne, and our current staff member, Rachel Apps.

The Library's location in Bldg 5 has been constant since its earliest days except that the Librarian and the photocopier occupy space that was that of the Chief Superintendent's secretary, and the Reading Room originally was the Chief Superintendent's office. The storage of an ever-increasing stock of reports, books, periodicals, etc., has created space crises for the Library several times. At one time, storage of older material had been done in at-that-time vacant space in Bldg 29 but pressures on that space caused relocation of this older material. By agreement, this older material now is stored in Bldg 17, the DSIS Bldg. In exchange, the DREO Library retrieves and replaces items from the DSIS collection for DSIS, essentially managing their archives.

The DREO Library originally also was the publishing arm of the Establishment, and undertook all the steps of having Report masters typed (Gestetner masters), illustrations prepared and reproduced by zinc-plate offset printing technology, photographs prepared and mounted, and then the final steps of reproduction, collation, binding, and distribution. This system lasted until roughly 1972 when the services of DSIS were utilized to produce a much more professionally-printed finished report. This arrangement prevailed until approximately 1982 when the Library was split. Two new groups, Information Services and Publications, were formed. In 1986, the Publications Group was formally split off to become the Publications Section.

Photography

The Photographer originally came under the Library. Romelda Parks was the first photographer at the Shirleys Bay site, followed by Dave Bishop. The Photography Lab then was put under the NBC Division and was headed up, in succession, by Bill Harrington, Marcel Paquette, Scotty Yool, and Marcel Paquette again. While Marcel was photographer, DREO's Photography Lab was closed and Marcel worked out of Communications Research's photography lab. In 1985, Marcel moved back to DREO as part of the Publishing Section, in the new Program Support Division. On his retirement, Bill Townson took charge of Photography.

The first location of the Photography Group was in the basement of Bldg 4 (before the Bldg 4/5 tunnel was constructed). Under Bill Harrington, the facility moved to Bldg 29. After its replacement by the electronically shielded room, it relocated within Bldg 29, opposite DREO Stores. On Bill's retirement, the facility closed and was merged with CRC's Photography group and Marcel Paquette was relocated to CRC quarters. Eventually, Photography was repatriated to DREO and, under Marcel, was established on the second floor of Bldg 5. In a very recent move, these quarters were closed and a new facility, under Bill Townson, was opened in the basement of Bldg 5C.

The Office of the Chief

By 1967, a major shift of responsibilities for staff work from DRB HQ to Establishments occurred and a formal organization within the Chief Superintendent's Office, the Office of Scientific Staff Duties (OSSD), was created to provide a structural framework to accommodate the Staff Officers transferred from Headquarters. The first Head of OSSD was Charlie Hubley. At the same time, OSSD took over the responsibility for the Library and the Head of OSSD was made the Technical Editor, screening all publications at their final-draft stage before Chief's sign-off. The Library remained the DREO Agency for publishing DREO's papers. It now arranged for any necessary photography or illustrative or drafting material work but left the final report printing, distribution, etc. to DSIS.

In 1969, because of the splitting off of DRTE from DRB, several miscellaneous elements of DRTE were transferred to DREO and some of these, for example, TLO (Vernon Smith) and DIR (Russ Lysons) eventually ended up as elements of the Chief's Office. In 1973, a formal "Office of the DG" (Dave Bulleid) was established which encompassed OSSD and the Library, and now DIR (transferred over from the new Defence Electronics Division). By 1978, DIR had been terminated and the Office of the DG had been renamed "Office of the Chief" and also incorporated the Scientific Executive Assistant (SEA). Harry Nash, Lloyd McDermot, and Ernie Criddle have filled this job. At the same time, a new element, Deputy Chief, DREO, with primary responsibility for the electronics programs at DREO was created. The first Deputy Chief was LeRoy Nelms. Later Deputy Chiefs were Graham Thistle and Bill Armstrong (acting).

In 1980, the Defence Electronics Division had been split to become the Electronics Division and the Electronic Warfare Division. The TLO function did not fit well into either of these new organizations and it was transferred to the Office of the Chief. The first Head of TLO in the Office of the Chief was Ross Abercrombie.*

In 1984, a new function was added to the Chief's Office, that of project management of the proposed military satellite, and an office, PMO DND MSAT, was added. Ross Abercrombie became "double hatted" as both Head of this PMO and of TLO. In 1986, the Library function was split into a Publications Section (Marion Ritchie) and an Information Section (Susan McIntyre), both reporting to Ross Abercrombie.

In 1987, the SEA position was converted to a more "staff-officer" oriented role and the name was changed to "Scientific Executive Officer". Ernie Criddle was the first SEA. Don Judd acted in this capacity for nine months and then a seconded Naval Officer, Lt(N) Haig Krikorian, took over until 1990. He was succeeded by Monna Capstick, the current SEO.

In 1988, a new entity, Director, Program Support Telecommunications Liaison, was created by combining functions of the old "Office of the Chief" and of the "Deputy Chief/DREO" positions. The first Director was Ross Abercrombie, the present Director is Bill Osborne.

The first secretary to the Chief, at John and Sussex Street, was Gloria Bradley. She moved to Shirleys Bay when DRCL moved but retired soon after. She was succeeded by Nadine Sears. For two years, in the early '60s, Nadine's assistant was Winnie Johnston. Nadine retired in 1981. Val Burnett who was the secretary to the Deputy Chief then was made secretary (acting) to the Chief and for several years, did both jobs, under Clay Iverson, Graham Thistle, and Bob Heggie. Cathy Gibb succeeded Val but only stayed a short time before moving on. The position remained vacant for some time, until 1990, when Lois Knaggs became the Chief's secretary.

With the creation of OSSD and, later, the Office of Chief, a second secretary was added to the "front office". The first was Lorraine Lachance, and then Chris Leveille. As the front-office function changed, elements of Deputy Chief, TLO, SEA, and PM DND MSAT were involved. Recently, "the second secretary" job has been filled by both Elaine McHale and Val Burnett. With creation of D/PSTL, this second secretary has become that of secretary to the new Director. Val Burnett currently holds this position.

EVOLUTION FROM TLO, AND THE PRESENT ORGANIZATION -

by LeRoy Nelms, Bill Osborne and Joan Ross

While the PSTL Division has been in existence only a short time, it has Sections and people who trace their origins to the earliest days of DREO!

Beginnings... (1969-1972)

The Program Support (Telecommunications Liaison) (PSTL) Division shared a part of its beginnings with those of the Electronic Warfare (EWD) and Electronics Divisions (ED). The 1969 agreement between DRB and DOC which saw the transfer of DRTE from DRB to the newly-created CRC provided for a program of research by CRC in support of DRB and a Telecommunications Liaison Office (TLO) which was set up within DREO to oversee the arrangement. The office originally consisted of a Telecommunications Liaison Officer (Walt Surtees, then Vern Smith and Bob Simpson), and was first located in CRC, then relocated to a small office on the 2nd floor of Bldg 5, DREO. This office then became part of the Defence Electronics and

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* TLO had been headed by Walt Surtees, Vernon Smith, Ted Thompson, and Ross Abercrombie while part of the Defence Electronics Division.

Navigation Division when Oscar Sandoz transferred to DREO to build up EW-based activities. The Division was directed by Walt Surtees. The Defence Industrial Research (DIR) Program transferred out from DRB HQ, operated by Russ Lysons, was incorporated into this Division.

The Connection with Defence Electronics... (1973-1979)

In 1973, Dr. Surtees returned to DRB HQ and LeRoy Nelms was appointed Director, with Pearl Hanna and Marie Kennedy (Crawford) as secretaries. The Division was reorganized to include Electronic Warfare and renamed. The term "Navigation" was removed from the title, as it was considered to be a mature technology. The DIR function, now headed by Vern Smith, (Russ Lysons having departed) was removed from the Division responsibilities to report directly to the Chief. For a short time Dr. Nelms wore "two hats" as TLO and Director until the appointment of Ted Thompson as acting TLO. Ted remained in place until Ross Abercrombie replaced him.

Heading West??... (1974)

In 1974, the Hon. James Richardson became Minister of National Defence, and it was decided that the Earth Sciences and Defence Electronics functions at DREO, as well as the Recoverable Radar program at CRC, would be transferred to Winnipeg (Mr. Richardson's home riding) to become the new DREM. Extensive planning was done, a large tract of land was purchased in the City of Winnipeg, and architectural drawings were prepared for the new DREM lab. Two years later, the plan was put on indefinite postponement and it languished in limbo ever since Mr. Richardson left the portfolio in 1976, until the mid-'80s when the plan for DREM was cancelled officially.

Deputy Chief and TLO... (1980-1983)

In 1980 the Defence Electronics Division was split: EWD and ED became Divisions, and TLO was transferred to the Office of the Chief. At the same time, a new office, Deputy Chief/DREO, was created. LeRoy Nelms became the first D/Chief with Val Burnett as secretary. It was during this time that the first Research and Development Program Information System (RDPIS) was produced by LeRoy Nelms by hand! The D/Chief oversaw the electronics-based activities including, of course, the recoverable program, while the Chief (Clay Iverson) had overall responsibility, and oversaw the Nuclear Biological Chemical (NBC), Energy Conversion, and Earth Sciences Division Programs.

TLO Evolves into PSTL...(1983-1989)

In 1983, Dr. Nelms moved temporarily to CRAD Headquarters to be Acting Associate CRAD and Graham Thistle was coerced into taking on the D/Chief's job. While Clay Iverson prepared to return to DRES, Bob Heggie became Chief in 1985 and Graham Thistle left to become Counsellor, Defence Research and Development in the UK. It was decided at that time that the position of Deputy Chief was no longer needed, but an organization should be established to provide the liaison function to CRC plus centralized services common to the Establishment. This led to studies to define a new organization which would encompass these responsibilities. While the studies defined the organization, it took the practised hand of Don Judd, then acting SEA to write all the job descriptions (PAS's) for the Division before PSTL could be brought to life officially . Ross Abercrombie was de facto the first Director, a position he held until his retirement. Bill Osborne replaced Ross Abercrombie as Director in 1989.

Included in the organization were elements which had very different beginnings. The Library section (including Publications) was originally a part of the Chief's office. The Records office was, for a short time a part of the Library organization, but was mainly in Admin until 1991 when it was restored to the Information Services Section under Susan McIntyre. Publications began its journey to independent section status in 1982. A Document Review Panel had existed since 1962 at DREO. Its original role was to review DREO documents with a view to downgrading or declassifying actions. It met sporadically, usually only when a document was actively under review for downgrading. In 1982, its function changed. It became a permanent panel and it now oversaw all phases of document control and review and arranged the publication of DREO documents, as well as carrying out the older security-review activities. Over the next few years the Publications Section expanded, acquiring responsibility for technical illustrations (Bob Gervais) and photography (Marcel Paquette, Bill Townson). While Don Judd acted as Section Head for a time, the first official head was Marion Ritchie. She continues in this function, ably assisted by Gwen Robertson.

The Computer Services Section has had a much shorter history. It was formed in 1985 as a function of Admin with Mark Gill as the first (and, so far, only) Section Head. Construction and site services management, currently under Joan Ross, also was within Admin. In 1991, both sections were transferred to the PSTL division.

Overall responsibility for training and conference coordination resided within PSTL for a few years but was transferred to Admin in 1991.

On the other hand, the model shop is new to PSTL. Its beginnings lie in antiquity. It moved to Shirleys Bay from John and Sussex Street when the site opened in 1953. Dave Norman was its first head at Shirleys Bay as it became part of the Engineering Section. W.E. Cowie became its acting head, he was succeeded by Adrian Ruddell, who, in turn, was succeeded by Dave Bulleid. The last Head was Jean Baillot. The Engineering Section was amalgamated with the Rubber and Plastics Lab and with the Pilot Plant to form the new Materials Section under Jim Wheat. At about this time, old-time machine-shop and drafting-room staff began to retire and could not be replaced, and the machine shop went into decline. Bill Dickson (who had come in 1957) became its supervisor and managed its outside contracts. In 1983 the machine shop became the model shop and was relocated to Bldg 5C from its original home in Bldg 6. Over the years staff levels continued to fall until only Bill Dickson remained. The staff level was doubled when Bill Barnes transferred in from ED. Overall responsibility for the model shop was transferred from PSD to PSTL in 1990.

The Way Ahead... (1991—)

The TLO, now headed by Martin MacKinnon, continues to oversee the current Recoverable Communications Research program at CRC. New additions to the Division, while adding a technical perspective, have placed further emphasis on the provision of services to the Establishment. After a lengthy period of definition, PSTL has reached a point of stability and stands ready to face the challenges of the future as a member of the establishment team.

CIVILIAN PERSONNEL OFFICE

by

Jim Norman

Before April 1974, DRB was a Separate Employer created under the National Defence Act, and personnel functions were the responsibility of DRB's Chief of Personnel. These responsibilities were discharged at DREO by having a clerk on the Administrative Officer's (later, the Director of Administration) staff, Lena Carmody, carry out the necessary duties. After DRB's demise, these responsibilities passed to DND (not a separate employer) and became a responsibility of DND's Chief of Civilian Personnel under the Public Service Act. DRB and DREO employees now came under that Act and the Public Service Commission. DREO's personnel-services needs were met by creation of a DND Civilian-Personnel-Unit (CPO/DREO) at DREO to provide Establishment employees with the services normally provided to other DND civilian employees by this Branch.

The CPO/DREO unit is co-located with DREO. It occupies space in Bldg 6 close to that of the Director of Administration. It is there to serve DREO but it is not part of DREO nor are its staff DREO staff. Its first Head was Pat Ellerton, one of the former DRB Personnel Officers (staff: John Bannerman, Eileen Kavanagh), succeeded by Lynn Sutherland, then by Donna Quinn (staff: Cheryl Bourdon, Eileen Kavanagh) and then Gerry Taylor (staff: Cheryl Bourdon, Grace Banning, Eleanor Kavanagh). The CPO/DREO Office then was incorporated into the CPO Mat-2 Office at NDHQ, supervision being provided by that Office, first, by Lorraine Blais, then by Donna (Quinn) Richard and later by Cheryl Bourdon. Staff resident at DREO are Grace Banning and Eileen Kavanagh).

SECURITY, SAFETY, AND HEALTH

by

Jim Norman

SECURITY

DREO's work, in large measure is, and always has been, highly classified. This includes the work done under our collaborative programs with our ABCA and NATO Allies, and to ensure adequate security for such classified work, the Establishment always has been "closed" (that is, not open to the general public). The site itself has been protected by a Site Security Service first, by the DRB Guard Service operated at Shirleys Bay by DRTE, and later by an equivalent service operated by CRC (see "The Guard Service" under ET CETERA). The interface to other security services, and also to the General Public, has been the DREO Security Officer. He oversees all matters dealing with security. He arranges for security clearances for all employees, and also ensures that clearances are proper for all visitors and/or visits both to or from DREO. For uncleared visits, he ensures proper escort of visitors. He supervises the custody system for classified material held by DREO, and makes arrangements for transmission, receipt, and distribution of classified material, and supervises the destruction of classified waste.

Until very recently, the Security Officer has been appointed from technical staff, and the security duties have been an extra duty. Since 1953 (the year the laboratories became functional at Shirleys Bay), the Security Officers have been: Wib Cowie, Bob Bannard, Bob Charest, Frank Bury, John Collyer, Capt. Ken Lockhart, and Frank Strain (acting). In 1986, a full-time position as the combined Security Officer and General Safety Officer was created and attached to the staff of Administration. Ray Gorman was (and still is) the first incumbent of this position: Al Benoit is his deputy.

HEALTH AND SAFETY

While these matters are now a joint activity, they were separate until 1988, when the Canada Labour Code Pt IV was amended. The amendment consolidated separate workplace Safety and Health Committees into a single Occupational Safety and Health Committee. This amendment also provided for mandatory union representation on, and co-chairmanship of, this committee.

Health

Previously, health and safety were acknowledged as inter-related, however, were treated separately. Health matters were largely the province of the site nurse. A small nursing unit had been established at Shirleys Bay by Health and Welfare Canada to provide occupational-health services to all employees on the site. She monitored the day-to-day health of the staff and created and maintained the health records for each employee because all sick leave forms were funnelled through her. She also operated a first-line medical facility for staff. She provided advice and guidance, for example to pregnant staff members, and also a quiet place for someone not feeling well or with a headache to lie down for an hour or so. She treated the minor cuts, scrapes, bruises, or similar mishaps, from workplace accidents, or sent them on for medical/hospital treatment when they were not so minor and would then participate in accident-reporting and assessment or conducting liaison to the Workman's Compensation Board from these more-serious injuries. She also would assist staff with minor medical matters, for example, changing a dressing, or taking a blood-pressure reading to assist the family physician.

This nursing unit also was the interface to the Occupational-Health and Medical-Services facilities of Health and Welfare Canada. These latter were used for work-related medical examinations, or for inoculations, etc., which might be required by duty travel, to give two examples.

Over the years, many nurses have been assigned to the Shirleys Bay nursing unit. Long-service incumbents included: Miss (?) Argent, Mrs. Ida Woodwark, Mrs. Norah Disley, Ms. Margaret Falls, Marie Morrisey and Theresa Scrannage -- these two ladies were on a job-share program -- Gail McEvoy, and the current site nurse, Pat MacLeod. Other ladies also have spent brief periods as site nurses at Shirleys Bay, some as temporary replacements, others for very short terms before moving on. Unfortunately, we do not have records of their names.

Safety

Driven by the extreme toxicity of many materials handled routinely within the Chemical Defence Program, safety always has been a major concern at DREO. Additionally, the move to Shirleys Bay, with its lack of any municipal fire-fighting service available, forced a fire-safety service on both DREO and DRTE. In the earliest years, a volunteer fire-brigade was organized: later, a fire station and a professional fire brigade was established on site and the volunteer service was disbanded. DREO opted to retain its Fire-Warden and Area-Fire-Captain organization which concentrated on ensuring the prompt evacuation of all personnel in an emergency and provided a means of accounting for all staff.

In the beginning, a Safety Officer and a Fire Warden were appointed by the Chief to look after all aspects of chemical and fire safety, but, as new technology areas were added, specialist safety officers also were added, to assist the Safety Officer, now renamed the General Safety Officer. For example, a Nuclear Defence program was added to DREO's responsibilities and x-ray, γ-ray, and radioactive isotope facilities were acquired. Before so doing, a licence for such material had to be obtained from the Atomic Energy Control Board and one condition of that board was that DREO appoint a qualified individual as Radiation Safety Officer. He then assisted the General Safety Officer in all matters related to Radiation Safety. Similarly, as DREO's technical programs have changed, the safety organization has added a Chemical Safety Officer, a BW Safety Officer (this position was closed out in 1969), a Laser Safety Officer, a Microwave Radiation Safety Officer, and deputies or alternates for all of these Safety-Officer positions.

In the early '70s a formal organization, the DREO Safety Committee, was formed, to ensure coordination of all safety elements within the establishment. Unions were invited to nominate representatives to this committee and ordinary staff members were invited to attend. This committee was chaired by the General Safety Officer and its members were: the Deputy Safety officer, the Radiation Safety Officer, the Fire Warden, Representatives from PIPSC and UNDE, and, ex-officio, the site nurse. In 1974, DND issued new instructions on the make-up of safety committees (DND P40(1)) and to comply, the DREO Safety Committee was reconstituted under the chairmanship of one of the Establishment's Directors (selected by the Chief), the General Safety Officer became the secretary of this committee, and the rest of the membership was unchanged.

This organization was in effect until 1988 when such committees became governed by the provisions of the Canada Labour Code Pt IV, which converted safety committees to "Occupational Safety and Health" committees, and made them a part of Labour-Management relations. This new committee carried equal union and management representation, and operated under co-chairs, that is, there was a management co-chairperson and a labour co-chairperson each chairing half of the meetings. At DREO, the members of the older organization, the specialist safety officers, were added to the committee as non-voting "ex-officio" members.

The individuals concerned have been:

1. General Safety Officers

   - pre-Shirleys Bay - Walter McLintock
   - at Shirleys Bay - Bob Bannard, Ron Haines, Bob Blanchfield, Colin Hyde, Jim Norman, Bob Hayashi, Keith Shaw, John Coleman, John Bovenkamp, Kim Dix, John Coleman (2nd term), Ray Gorman.

2. Deputy Safety Officers

   - Bob Blanchfield, Ron Haines, Jim Norman, Brian Cox, Bruno Zanette, Ray Miller, Keith Shaw, Ben Lacroix.

3. Fire Wardens

   - Ernie Criddle, Ken Haley, Jerry Richer, Fred Flynn, Lloyd Gallop, Rick Nolan.

4. Chemical Safety Officer

   - Ray Miller; Deputy - Ben Lacroix

5. Radiation Safety Officer

   - Eric Jones, Frank Bury, Alan Johnson, Frank Strain, Dave Benyon, Gary Pepper

6. Laser Safety Officer

   - Nicole Brousseau; Deputy - Gary Pepper

7. Microwave Radiation Safety Officer

   - Ron Martin

8. Chairman of the original DREO Safety Committee

   - Jim Norman

9. Chairmen of the revised DREO Safety Committee

   - Jay Greenblatt, Parr Tate, Jim Norman

10. Co-chairpersons of the DREO Occupational Safety and Health Committee

    - Management Co-Chairperson - Jim Norman
      Labour Co-Chairperson - Denis Pichette

ET CETERA

ET CETERA

by

Rita Crow and Jim Norman

This section is meant to be a final catch-all, to allow a few words firstly, about those services that were, strictly speaking, not properly part of DREO but contributed much to life at Shirleys Bay, secondly, about DREO elements that no longer exist, and thirdly, about odds and ends that don't fit in anywhere else,

CAFETERIA SERVICES

In the early days at the John Street and Sussex Drive location, the Chemical Warfare Labs had a small cafeteria run by Mrs. Rose. When the Shirleys Bay buildings were complete, Mrs. Rose came out to run the cafeteria here. The first cafeteria was located in the basement of Building 5. It then moved over to Building 4, occupying the top floor and became the site cafeteria. Operation of it was taken over by a combined Employees' Association Committee from DRCL and DRTE. In approximately 1962, the top floor of Bldg 4 was enlarged and the cafeteria expanded into the new space, occupying approximately its present facility. The new cafeteria was managed by Mrs. L. Cameron until its operation was taken over by Public Works and contracted out. Lorne Murphy Foods is the third, and longest-standing contractor, continuing to provide good cafeteria service to this day.

TELEPHONES

There were very few telephone lines running into Shirleys Bay (from 1953 to 1960, there were two lines only), and there was a local switch board. The two switchboard operators (on DRTE strength) were located in Building 4 in a room to the left of the water fountain. In-house calls needed the switch board to interconnect at first, but by about 1956, it became possible to dial site locals. The operators knew everyone and could tell callers who was on the Site, who was away and who was at coffee! The switchboard was switched to the guard house at night.

Because of security restrictions and very limited access to the site, Bell Canada had one man, Bill Hamilton, cleared and assigned almost full time to Shirleys Bay. Bill integrated himself well into the work environment here and even attended many of the social events such as the Christmas parties and dances.

TRANSPORTATION

When the Site was opened, the DRCL employees who worked at John Street or at NRC were transferred here, but, because of the remoteness of the site, it was part of the condition of employment that DRB would run a bus system for employees, at least until the public transit system had expanded enough to service the Shirleys Bay site. Originally this bus system was operated by the Army's No. 9 Transport Company. Later it was contracted out to Colonial Coach Line (orange buses) which reorganized to become Voyageur. These Voyageur buses ran from the bus terminal on Albert Street to Shirleys Bay. By 1953, 5 buses were coming here. More buses were added as the number of employees increased, eventually reaching eight. As costs of running the buses went up, a fee was charged. When the government withdrew its support, the employees took over and attempted to maintain this charter service, but it collapsed in 1976. OC Transpo had the rights to the urban transport route and, when the charter activity stopped, started a regular service to the Site.

Transport was also provided by a four-times-daily jitney service from No. 9 Transport Co. using 9-passenger vans, until 1974, when it was replaced by a shuttle service operated by DREO and CRC Transportation Units. The DREO transportation unit also provided site and local transport: to meetings, to pick up and deliver VIPs to airports or train stations, and also could provide a vehicle for use on long trips, on field trials, etc.

These services ended in 1986 when the DREO transportation unit was fully merged with that of CFB Ottawa.

THE FIRE STATION AND FIRE ALARMS

Again, because of remoteness, a full-time site fire station was operated by DRTE. This was augmented by a volunteer fire brigade and DREO had the responsibility of evacuating its own buildings and checking on the evacuation, and had a Fire Warden Organization to do this. The Chief Fire Warden for almost 25 years was Ernie Criddle. Since then, there have been a series of short-term appointments of many different individuals. To assist the Fire Warden, a number of individuals were designated as fire captains. Each had a specific block of laboratories to check to ensure evacuation was complete. At DREO, this system was used for all evacuations regardless of cause (fire, gas, etc.).

DREO'S AMBULANCE

In its earliest days, a Medical Officer from the Surgeon-General's staff was posted to DRCL to participate in the chemical defence research program and could provide medical coverage in case of an accident with a chemical agent. The Medical Officer was withdrawn in 1960 and the only medical assistance on site was that from the Health and Welfare Nurse assigned to Shirleys Bay. While recognizing this to be unsatisfactory, it took three years to arrange to have one of DREO's older vehicles converted to an ambulance, so that a chemical-agent-poisoning victim could be transferred to the new NDMC. This service was maintained at DREO until 1978, when it was felt that the service could be better provided by the Province-of-Ontario Ambulance Service.

THE GUARD SERVICE

The original security service at Shirleys Bay was provided by the DRB Guard Service who had men posted at the main doors of almost all buildings on site (a few with service functions only and without lab facilities, for example, Bldgs 4 and 6, were "open", that is, without guards). Other doors were locked. All employees signed into the buildings, some signed out on leaving. Visitors signed a visitors registry kept by the guard: uncleared visitors were held until an escort arrived, cleared visitors were allowed to proceed.

Later, the security system was changed to one of perimeter security. The site was fenced, and the guards now controlled entry to the site through the main gate/guardhouse. A pass system was instituted to allow employees access, but visitors were still required to register at the Guardhouse, and were held there until arrangements had been completed to receive the visitor. This system was taken over by CRC after DRTE's separation from DRB but it operated unchanged until approximately 1984 when the guards (employees) were replaced by commissionaires (contract service) as they retired. In 1988, an electronic security system was added. An employee-pass-card now was required to enter a building or any restricted area on the site. This pass-card system could be set to be very selective, allowing only very small groups of employees access to restricted areas, if such was deemed appropriate. Visitors still require an escort.

CLEANING STAFF

At one time, the site had its own cleaning staff These were cleared individuals employed by DRB, and on strength at DRTE. They provided cleaning services to DREO. In 1964, building cleaning became a contracted-out activity. Most of the former cleaning staff were able to transfer to the employ of the cleaning contractor.

Since 1964, there have been a multitude of cleaning firms at Shirleys Bay; however, there has been one constant -- none of the contactors have managed to keep DREO as clean as the original DRB Staff!

THE ANIMAL KEEPERS

As part of the consolidation of DRKL's biological programs at DRCL, an animal facility, Bldg 29, was established. This facility supplied mice, rats, guinea pigs, and rabbits on a routine basis to the programs of those days and could provide dogs, cats, or hamsters if advance warning was given. Breeding colonies of mice, rats, and guinea pigs were operated by the Head Animal Keeper and his two assistants. As the toxicology programs and biological defence programs were shifted out of DREO, animal keeping and animal care was cut back. When the Radiation Biology program was consolidated at NRC with the similar NRC program, the animal keeper positions were loaned to NRC as part of the DREO contribution and the animal keepers transferred to NRC. This prevailed until their retirements. The two positions then were closed out.

GLASSWARE CLEANING/STERILIZATION SERVICES

The Chemical and Biological Programs had a need for extra cleaning of glassware to ensure the last traces of dangerous substances had been completely inactivated. For chemical-agent contaminated glassware beyond the cleaning abilities of conventional laboratory techniques, a glassware-cleaning specialist, Phil Beauchamps, was employed. This service continued until Phil's retirement in 1968. A similar system was operated to provide sterile materials to the laboratories for biological work. Routinely, sterile glassware, towels, agar plates and stock solutions were prepared by a sterilization specialist and supplied to the biological laboratories. A second specialist arranged sterilization of used glassware and other equipment, animal carcasses, etc. before they were removed from the biological labs. He also provided sterile animal-keeping equipment: cages, drinking water, water bottles and supplies, food dishes, etc. In 1969, when the Biological Defence Program was transferred to DRES, the autoclaves, etc. to operate this system also was transferred and the sterilization system was terminated.

THE BRINKS CHEQUE-CASHING SERVICE

In the '50s and '60s, bank hours (10 AM to 3 PM Monday to Friday, and an extra period, 4:30-6 PM on Fridays) were much more limited than today and most employees at Shirleys Bay could not easily get to a bank. A common payday had been established for DRCL and DRTE employees and Brinks Security Service (now, Brinks Cda Ltd) came to the site every payday and cashed people's cheques for them for a fee of 25 cents. In 1969, when CRC was split off from DND, it was put on "first payday" and DRCL was on "second payday". Neither payday was large enough to warrant the Brinks service and it collapsed about a year after the splitting of paydays.

THE EMPLOYEE'S ASSOCIATION

The Employees' Association was formed very early on, in approximately 1955. At the time, there was an announced move of DRCL to Kingston and many employees left for other jobs in Ottawa. Because there were so many departures, it was decided to form the EA, and charge a membership fee to buy gifts for departing employees, to stop the multitudinous solicitations.

In the early '50s and '60s, there were very few retirements, however, 30 to 35 years after the formation of DRB, there a flurry of them, to the extent that the Christmas Dance was transformed into a Retirement dinner/dance. The support for the dinner/dance petered out when it became possible to retire at any time of year.

The EA also took over social functions which were previously organized by interested employees. The social events have stayed more or less the same over the years with a golf tournament, a summer picnic (at Lac Philippe, Lemay Lake, Hog's Back Park, Vincent Massey Park, car rally to Carleton Place, and the picnic and truck fire at Britannia), baseball games, a cook-out, a fall dinner-dance, the aforementioned Christmas Party and Dance, a Christmas Party for the children with Joe Webb and later Oscar Chambers as Santa, and the famous in-house Christmas parties the morning before the Christmas holiday which included a concert organized by Dr. Casey. (At one memorable party, Dr. Casey's sermon was interrupted by Drs. R.M. Heggie and R.A.B. Bannard as chief mourners, having a coffin full of "dead soldiers" piped in by our resident professional piper, Dave Benyon.) A curling bonspiel has been added recently.

MISS DRCL, MISS DRB, AND MISS CIVIL SERVICE CONTESTS

Back in the (good?) old days of "sexist" activities, there was a Miss Civil Service contest, government wide. A Miss DRB Contest was a preliminary to this larger contest. There was a mid-summer party, with a contest to select Miss DRB from local DRB Establishment/HQ Directorate candidates such as Miss DRCL, Miss DSIS, Miss DRTE, and Miss DRAE. It came to an end in the early seventies.

THE 10-YEAR CERTIFICATE AND OTHER LONG-SERVICE AWARDS

DRB was unique in that it was the only Federal-Government Institution that formally recognized 10 years of service. This came about because DRB's first Chairman retired 10 years after his appointment and a certificate for 10 years of "loyal and meritorious service" was authorized for him. Subsequently, a 10-year certificate was given to all DRB employees after their 10th year of service.

In addition, the federal government gave plaques for 25 years and medals for 35 years of faithful work.

POSTSCRIPTS

FURTHER ACHIEVEMENTS OF SOME DREO ALUMNI

by

the Editors

Dr. E.A. Flood, while in uniform, became the first superintendent of what is now DREO. During WWII, as Lt Col Flood, he operated a major portion of Canada's Chemical Warfare Program. In 1945 he was awarded an OBE in recognition of his outstanding contributions to Canada's defence both before and during WWII.

Dr. Flood returned to NRC after the war, becoming Principal Research Scientist in the Division of Chemistry and remaining active in R&D until his retirement.

Jack Dacey left DRCL to become Professor of Chemistry at Royal Military College. He went on to become the Principal of the College and oversaw the conversion of the College into a bilingual Institution and also its conversion to University status. He retired as Principal, but refuses to stop working. He continues to come to the College nearly every day, to pursue research as an emeritus Professor of Chemistry.

Harry Sheffer was our longest-standing Chief, being the Chief Superintendent of DREO under 3 of its former names, DRCL, DRCL/KL and DCBRL, and also was Chief Superintendent of DRKL simultaneously. He left to become, first, Chief, NBC Defence Programs at DRBHQ and then, Vice-Chairman, DRB, holding this latter position until his resignation from public service.

Mace Coffey left DREO for Operational Research for the Navy at Halifax, and then went on to become Scientific Advisor to the then-newly-created Commander, Northern Region, at Yellowknife, NWT. In appreciation of his contributions to operations in the north, he was honoured by having a mountain peak on Devon Island, "Mount Coffey", named for him.

Bob McIvor left the field of Chemical Warfare to become a Computerized-Information specialist and became Director-General of the Defence Science Information Service.

Bob Heggie left DREO for a series of senior appointments within CRAD: as Chief, DRES; Chief, DCIEM; Chief, DREO; and then at CRAD HQ, as Associate CRAD, until his retirement.

Charlie Hubley, after leaving the Office of the Chief at DREO was, briefly, the Director of Atomic Research (the new name for the Special Weapons Directorate) and then took up a series of overseas appointments, becoming the Counsellor, Defence Research and Development with the Canadian High Commission in London, England, and later, the same position, Counsellor, Defence Research and Development at the Canadian Embassy in Washington, returning to Canada just prior to his retirement.

Adrien Leger left DREO to become the Secretary to DRB, and later, the Counsellor, Scientific, at the Canadian Embassy in Paris, France.

Jay Greenblatt joined DREO from DREA to become the first Director of the Earth Sciences Division. He was selected to be the first Chief of the new DRB Establishment at Winnipeg, the Defence Research Establishment Manitoba (DREM). While awaiting the construction for DREM, he accepted an appointment as Counsellor, Defence Research and Development, in Washington. When DREM was cancelled, he agreed to serve an extra year in Washington, and then retired.

Moira Dunbar of the Earth Sciences Division was honoured with an Order of Canada in 1976, in recognition of her outstanding scientific contributions to Arctic Studies.

Jerry Casey had been offered the position of C/Plans in the CRAD HQ organization but, before he could take up this appointment, he suffered a stroke and cerebral haemorrhage from which he never recovered, lying in a coma for nearly six years until his death.

Jim Flynn succeeded Harry Sheffer as Chief Superintendent. He left DREO to take up the appointment of Chief, DREP which he held until his retirement.

Bill Armstrong became Deputy Chief, DREO, but then left to become Associate DG Operations and later, DG Operations at CRAD HQ until just prior to his retirement.

Jack Currie moved to DRES when the BW program was transferred there from DREO and rose to become the Director of Research and then the acting Chief of that Establishment until his retirement.

Charlie Clifford left DREO for CRAD HQ, becoming the first Director of Science and Technology for Human Performance and then Director of Research and Development (Human Performance). He returned to DREO to become Director of the Protective Sciences Division but also expanded his International Science activities to become the Executive Chairman of Subgroup E under TTCP; the Canadian Leader of Theme 11 (NBC Defence) under the Franco-Canadian Accord; and the first Canadian National Leader of the Canada-Netherlands Bilateral Agreement of CB Defence.

Clay Iverson came to DREO to become Chief, having held that position at DRES. He later returned to DRES, as Chief again, just prior to his retirement from public service.

LeRoy Nelms came from CRC, to take over the fledgling (at that time) Electronics Programs being established at DREO, becoming first the Director of the Defence Electronics Division, and then the Deputy Chief. His next appointment was to CRAD HQ as the first Associate CRAD. Later, he returned as Chief, DREO, the position he held until his retirement.

LeRoy Pearce also came to DREO from CRC, to become Director of the Electronics Division. He then accepted a position as Director, Research and Development Communications and Space at CRAD HQ, and then returned as Chief, DREO in the fall of 1990.

Ken Peebles left DREO for CRAD HQ and served several staff appointments before being appointed Chief, DREV. In early June 1992, Ken was appointed CRAD, to succeed Dr. D. Schofield.

ANNEX A

ORGANIZATION OF DREO

1941 - 1991

Compiled by Jim Norman

1941 - 1943

Chemical Warfare Laboratory (CWL)

Officer-in-Charge - Dr. O. Maass (interim)
LCol E.A. Flood

Respirator Assembly Plant (RAP)

Officer-in-Charge - various

Pilot Plant (PP)

Officer-in-Charge - various

1944 - 1945

Chemical Warfare Laboratories (CWL)*

Superintendent - LCol. E.A. Flood

Groups:
- Detection
- Organic Chemistry
- Flamethrower Fuels
- General Chemistry
- RAP
- Pilot Plant

1946 - mid-1947

Chemical Warfare Laboratories (CWL)

Superintendent - Dr. J.R. Dacey
Administration

Groups:
- Detection
- Organic Chemistry
- Flamethrower Fuels
- Fluorine Chemistry
- Pilot Plant
- Respirator Assembly Plant
- Physical Testing
- Atmospheric Pollution Studies Detachment, Windsor, Ontario

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* Amalgamation of CWL, RAP, and PP.

mid-1947 - 1952

Defence Research Chemical Laboratories (DRCL)[a]

Superintendent - Dr. J.C. Arnell

Administration - Mr. W. McLintock

Library - Miss E.A. Lang

Groups[b]:
- Detection
- Organic Chemistry
- Fluorine Chemistry
- Electrochemistry and Batteries (added 1950)
- Flamethrower Fuels
- Protective Equipment
- Pilot Plant
- Respirator Assembly Plant

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[a] New name of Establishment.

[b] Atmosphere Pollution studies transferred to other Government Departments, DRB involvement terminated in 1952.

1952 - 1954

Defence Research Chemical Laboratories (DRCL)

Superintendent - Dr. J.C. Arnell (1952-53)

Deputy Superintendent - Dr. H. Sheffer (1954) acting

Administrative Officer - Mr. W. McLintock
Supply - Mr. K.J. Haley
Finance - Mr. W. McLintock
Central Registry - Mrs. L. McDermot

Library Services - Miss. E.A. Lang

Groups:	Detection	Mr. G.A. Grant
	Organic Chemistry	Dr. A.F. McKay
	Electrochemistry	Dr. E.J. Casey
	Fluorine Chemistry	Dr. J. Dale
	Flamethrower Fuels	Dr. H. Sheffer
	Protective Equipment	Mr. W.E. Cowie
	Pilot Plant	Sqn Ldr T. O'Neil/ Mr. Chmilar/ Mr. J.A. Wheat (1953)
	Respirator Assembly Plant	Dr. T.E. King
	Radiation Physics Group	Dr. J.A. Carruthers (added 1953)
	Radiation Chemistry Group	Mr. G.A. Grant (added 1954)

1955 - 1960

Defence Research Chemical Laboratories/Kingston Laboratories (DRCL/KL)[a]

Superintendent DRCL/KL - Dr. H. Sheffer (1955-1957)

Chief Superintendent[b] DRCL/KL - Dr. H. Sheffer (1958-1960)

Deputy Chief Superintendent DRCL/KL - Mr. N.J.B. Wiggin (1957-1960)

Administrative Officer - Mr. W. McLintock
Deputy Administrative Officer DRKL - Mr. O.P. Chambers (1956-1960)
  Finance - Mr. W. McLintock
  Supply - Mr. K.J. Haley
  Central Registry - Mrs. L. McDermot

Library Services - Miss. E.A. Lang

Atomic Warfare Defence Section (DRCL)[c] - Dr. J.A. Carruthers (1955-59)
 - Dr. J.T. Flynn (1960)
Chemical Warfare Section (DRCL/KL)[d] - Mr. G.A. Grant
Protective Equipment Section (DRCL)[e] - Mr. W.E. Cowie
Biological Warfare Section (DRKL) - Mr. J. Currie
General Chemistry Section (DRCL)[f] - Dr. H. Sheffer

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[a] Name reflects incorporation of Defence Research Kingston Laboratories (DRKL) into DRCL.

[b] Title of head of laboratory changed from Superintendent to Chief Superintendent.

[c] Radiation Physics and Radiation Chemistry Groups merged into Atomic Warfare Section.

[d] Detection, Organic Chemistry, Fluorine Chemistry, Toxicology (DRKL) Groups merged into Chemical Warfare Section.

[e] Protective Equipment, Pilot Plant, Respirator Assembly Plant and Rubber and Plastics Lab Groups merged into Protective Equipment Section.

[f] Electrochemistry and Flamethrower Groups merged into General Chemistry Section.

1961 - 1962

Defence Research Chemical Laboratories
(DRCL)*

Chief Superintendent - Dr. H. Sheffer

Administrative Officer - Mr. W. McLintock
    Supply - Mr. K.J. Haley
    Finance - Mr. O.P. Chambers
    Central Registry - Mrs. L. McDermot

Library Services - Miss E.A. Lang

Atomic Wing
Superintendent - Dr. J.T. Flynn
    Physics Section - Dr. J.T. Flynn
    Radiation Biology & Chemistry Section - Mr. G.A. Grant

Biological and Chemical Wing
Superintendent - Dr. H. Sheffer (acting)
    Biological Warfare Section - Mr. J.F. Currie
    Chemical Warfare Section - Mr. G.A. Grant/Dr. R.M. Heggie
    General Chemistry Section - Dr. C.E. Hubley
    Power Sources Section - Dr. E.J. Casey

Development Wing
Superintendent - Mr. W.E. Cowie
    Physics and Test Section - Mr. L.G. Wilson
    Chemistry Section - Dr. H.L. McDermot
    Rubber & Plastics Lab - Mr. H.L. Nash
    Engineering Section - Mr. P.A. Ruddell
    Pilot Plant - Mr. J.A. Wheat
    Respirator Assembly Plant - Dr. T.E. King

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* The Kingston Laboratories were closed in 1960 and work moved to Ottawa.

1963 - 1966

Defence Research Chemical Laboratories
(DRCL) 1960-1963

Defence Chemical Biological and Radiation Laboratories[a]
(DCBRL) 1964-1966

Chief Superintendent - Dr. H. Sheffer
    DCBRL Library - Miss. E.A. Lang
    Photography - Mr. W. Harrington

Administrative Officer - Mr. W. McLintock
    - K. Gibson (1966)
    Finance - O. Chambers
    Supply - K.J. Haley
    Central Registry - Mrs. Moody

Atomic Wing
Superintendent - Dr. J.T. Flynn
    Radiation Physics - Dr. J.T. Flynn
    Radiation Measurements - Dr. P.A. Tate
    Radiation Biology and Chemistry - Mr. G.A. Grant

Biological and Chemical Wing
Superintendent - Dr. H. Sheffer (Acting)
    Biological Warfare - Mr. J.F. Currie
    Chemical Warfare - Dr. R.M. Heggie
    General Chemistry and Services - Dr. H. Sheffer (Acting)
    Power Sources - Dr. E.J. Casey

Development Wing
Superintendent - Mr. W.E. Cowie
    Physics and Test - Mr. L.G. Wilson
    Chemistry - Dr. H.L. McDermot
    Rubber & Plastics Lab - Mr. H.L. Nash
    Engineering - Mr. P.A. Ruddell
    Pilot Plant - Mr. J.A. Wheat
    Respirator Assembly Plant[b] - Dr. T.E. King

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[a] Name change, 1964.

[b] The Respirator Assembly Plant was transferred to the Canadian Army in 1965.

1967 - 1968

Defence Chemical Biological and Radiation Establishment
(DCBRE) - 1967[a]

Defence Research Establishment Ottawa (DREO) - 1968[a]

Director General[b] - Dr. J.T. Flynn (1967) (Acting)
- Dr. J.T. Flynn (1968)

Office of Scientific Staff Duties - Dr. C.E. Hubley
Library - Miss. E.A. Lang
Photography - Mr. W. Harrington

Director of Administration
Director - Mr. J.K. Gibson (acting)
Finance - Mr. O.P. Chambers
Supply - Mr. K.J. Haley
Central Registry - Mrs. Moody

Atomic Division[b]
Director - Dr. J.T. Flynn
Radiation Physics Section - Dr. C.E. Clifford
Radiation Measurements - Dr. P.A. Tate
Radiation Biology and Chemistry - Mr. G.A. Grant

B&C Division[b]
Director - Dr. M.K. McPhail
BW Section - Mr. J.F. Currie
Chemical Defence Section[c] - Dr. R.M. Heggie

Development Division[b]
Director - Mr. W.E. Cowie
Physics and Test Section - Mr. L.G. Wilson
Chemistry Section - Dr. H.L. McDermot
Engineering Section - Mr. W.E. Cowie (1967) (Acting)
- Mr. D.L. Bulleid (1968)
Pilot Plant - Mr. J.A. Wheat
Rubber & Plastics Lab - Mr. H.L. Nash

Electrical Power Sources Division[e]
Director - Dr. E.J. Casey
Power Sources Research - Dr. I.H.S. Henderson
Power Sources Design & Dev't - Dr. T.E. King

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[a] Establishment name changes 1967 and 1968.

[b] Title of Head of Laboratory changed from Chief Superintendent to Director-General; Wings renamed to Divisions under Directors.

[c] Chemical Warfare Section renamed Chemical Defence Section.

[d] General Chemistry and Services Section disbanded. Magnetic spectroscopy Group attached to Chemical Defence Section.

[e] Power Sources Section expanded into Electrical Power Sources Division.

1969

Defence Research Establishment Ottawa (DREO)

Director-General - Mr. R.F. Wilkinson

Office of Scientific Staff Duties - Dr. C.E. Hubley
    DREO Library - Miss E.A. Lang
    Photography - Mr. W. Harrington

Director of Administration - Mr. J.K. Gibson
    Finance - Mr. O. Chambers
    Supply - Mr. K.J. Haley
    Central Registry - Mrs. Moody

NBC Defence Division[a]
Director - Dr. R.M. Heggie
    Nuclear Sub-Division D/Director - Dr. P.A. Tate
        Radiation Measurements Section - Dr. P.A. Tate
        Radiation Physics Section - Dr. C.E. Clifford
        Radiation Biology Section - Mr. G.A. Grant

    Protection Sub-Division D/Director - Mr. W.E. Cowie
        Physics and Test Section - Mr. L.G. Wilson
        Engineering Section - Mr. D.L. Bulleid
        Pilot Plant - Mr. J.A. Wheat

    Chemical Defence Section - Dr. H.L. McDermot
        Rubber & Plastics Lab - Mr. H.L. Nash

Electrical Power Sources Division
Director - Dr. E.J. Casey
    Power Sources Research Section - Dr. I.H.S. Henderson
    Power Sources Design and Dev't - Dr. T.E. King

Miscellaneous Elements from DRB HQ and DRTE
    Telecommunications Liaison Office - Dr.W.J. Surtees
    Defence Industrial Research Gp[b] - Mr. H. Lysons
    Geophysics Section[b] - Mr. T.A. Harwood

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[a] Former Atomic, B&C, and Development Divisions merged into NBC Defence Division.

[b] Telecommunications Liaison Office (new), Geophysics Section from DRTE, Defence Industrial Research Group from DRB HQ.

1970 - 1971

Defence Research Establishment Ottawa (DREO)

Director General - Mr. R.F. Wilkinson

Office of Scientific Staff Duties - Dr. C.E. Hubley (1970)
- Mr. D.L. Bulleid (1971)
DREO Library - Miss E.A. Lang
Photographer - Mr. W. Harrington

Director of Administration - Mr. J.K. Gibson
Finance - Mr. O. Chambers
Supply - Mr. K.J. Haley
Central Registry - Mrs. A. Desjardins

NBC Defence Division
Director - Dr. R.M. Heggie
Nuclear Sub-Division D/Director - Dr. P.A. Tate
Rad. Measurement Section - Dr. P.A. Tate (1970)
- Dr. C.E. Clifford (1971)
Radiation Physics Section - Dr. C.E. Clifford
Radiation Biology Section - Mr. G.A. Grant

Protection Sub-Division D/Director - Mr. W.E. Cowie
Physics and Test Section - Mr. L.G. Wilson
Engineering Section - Mr. D.L. Bulleid (1970)
- Mr. J.A. Baillot (1971)
Pilot Plant Section - Mr. J.A. Wheat
Exploratory Studies Gp - Mr. W.E. Cowie

Chemical Defence Section - Dr. H.L. McDermot
Rubber and Plastics Lab - Mr. H.L. Nash

Electrical Power Sources Division
Director - Dr. E.J. Casey (1970)
Power Sources Research Section - Dr. G.D. Nagy
Power Sources Design and Dev't - Dr. T.E. King

Earth Sciences Division (new)[a]
Director - Dr. J.H. Greenblatt
Deputy Director - Mr. T.A. Harwood
Ice Research Section - Dr. G.F. Hattersley-Smith
Remote Sensing Section - Dr. I.H.S. Henderson

Telecommunications Liaison Office
Director - Dr. W.J. Surtees
Liaison Office - Mr. V. Smith
Defence Industrial Research Office - Mr. H. Lysons
Electronics Section (added)[b] - Mr. O.A. Sandoz

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[a] New Earth Sciences Division formed from Geophysics Section.

[b] Electronics Section added to Telecommunications Liaison Office

1972

Defence Research Establishment Ottawa (DREO)

Director-General - Mr. R.F. Wilkinson

Office of Scientific Staff Duties - Mr. D.L. Bulleid
- DREO Library - Miss. E.A. Lang
- Photography - Mr. W. Harrington

Director of Administration - Mr. J.K. Gibson
- Finance - Mr. O. Chambers
- Supply - Mr. K.J. Haley
- Central Registry - Mrs. A. Desjardins

NBC Defence Division
Director - Dr. R.M. Heggie
- Nuclear Effects Section - Dr. C.E. Clifford
- Radiation Biology Section - Mr. G.A. Grant
- Protection Sub-Division D/Director - Mr. W.E. Cowie
- Exploratory Studies Section - Mr. W.E. Cowie
- Physics and Test Section - Mr. L.G. Wilson
- Engineering Section - Mr. J.A. Baillot
- Materials Section - Mr. J.A. Wheat
- Chemical Defence Section - Dr. H.L. McDermot

Electrical Power Sources Division
Director - Dr. E.J. Casey
- Power Sources Research Section - Dr. G.D. Nagy
- Power Sources Design and Dev't - Dr. T.E. King

Earth Sciences Division
Director - Dr. J.H. Greenblatt
- D/Director - Mr. T.A. Harwood
  - Geotechnical Gp - Mr. I.S. Lindsay
  - Ice Research Section - Dr. G.F. Hattersley-Smith
  - Remote Sensing Section - Dr. I.H.S. Henderson

Defence Electronics Division (new)*
Director - Dr. W.J. Surtees
- Telecommunications Liaison Office - Mr. V. Smith
- Defence Industrial Research Section - Mr. H. Lysons
- Electronic Warfare Section - Mr. O.A. Sandoz

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* Formation of Defence Electronics Division from former Telecommunications Office.

1973 - 1974

Defence Research Establishment Ottawa (DREO)

Director-General - R.F. Wilkinson

Office of the Director-General - Mr. D.L. Bulleid (1973)
- Mr. H.L. Nash (1974)
DREO Library - Mrs. E.A. Greene
Photography - Mr. W. Harrington
Defence Industrial Research Office[a] - Mr. V. Smith
(from Defence Electronics)

Director of Administration - Mr. J.K. Gibson
Finance - Mr. O.P. Chambers
Supply - Mr. K.J. Haley
Central Registry - Mrs. A. Desjardins

NBC Defence Division
Director[b] - Dr. R.M. Heggie / Dr. C.E. Clifford (1973) (acting)
Nuclear Effects Section - Dr. C.E. Clifford
Radiation Biology Section - Mr.G.A. Grant
Chemical Defence Section - Dr. H.L. McDermot
Environmental Protection Section - Mr. L.G. Wilson
Materials Section - Mr. J.A. Wheat
Engineering Section - Mr. J.A. Baillot

Electrical Power Sources Division
Director - Dr. E.J. Casey
Primary Power Sources Section - Dr. G.D. Nagy
Rechargeable Systems Section - Dr. R.M. Hayashi

Earth Sciences Division
Director - Dr. J.H. Greenblatt
Geotechnical Section - Dr. I.M. Dunbar
Remote Sensing Section - Dr. I.H.S. Henderson

Defence Electronics Division
Director - Dr. G.L. Nelms
Telecommunications Liaison Office - Mr. E.A. Thompson
Electronic Warfare Section - Mr. O.A. Sandoz

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[a] Transfer of Defence Industrial Research Office to newly formed Office of the Director-General.

[b] Transfer of Elements of Protection Subdivision to Sections within the NBC Defence Division.

1975

Defence Research Establishment Ottawa (DREO)

Director-General - Mr. R.F. Wilkinson

Office of the Director-General - Mr. H.L. Nash
    DREO Library - Mrs. E.A. Greene
    Photography - Mr. W. Harrington
    Defence Industrial Research Office - Mr. V. Smith

Director of Administration - Mr. J.K. Gibson
    Finance - O.P. Chambers
    Supply - K.J. Haley
    Central Registry - Mrs. A. Desjardins

NBC Defence Division
Director - Dr. R.M. Heggie
    Nuclear Effects Section - Dr. C.E. Clifford
    Radiation Biology Section - Mr. G.A. Grant
    Chemical Defence Section - Dr. H.L. McDermot
    Environ. Protection Section - Dr. J.A. McAndless
    Materials Section - Mr. J.A. Wheat
    Engineering Section - Mr. J.A. Baillot

Electrical Power Sources Division
Director - Dr. E.J. Casey
    Primary Power Sources Section - Dr. G.D. Nagy
    Rechargeable Systems Section - Dr. R.M. Hayashi

Earth Sciences Division
Director - Dr. J.H. Greenblatt / Dr. I.M. Dunbar (Acting)
    Geotechnical Section - Dr. I.M. Dunbar
    Remote Sensing Section - Dr. I.H.S. Henderson
    Entomology Gp - Mr. I.S. Lindsay

Defence Electronics Division
Director - Dr. G.L. Nelms
    Electronic Warfare Section - O.A. Sandoz
    Telecommunications Liaison Office - E.A. Thompson

1976

Defence Research Establishment Ottawa (DREO)

Chief[a] - Mr. C.R. Iverson
- Dr. G.L. Nelms (1976) (acting)

Office of the Chief - Mr. H.L. Nash
DREO Library - Vacant
Photography - Mr. W. Harrington
Defence Industrial Research Office[b]

Director of Administration - Mr. D. Blakely
Finance - O.P. Chambers
Supply - K.J. Haley
Central Registry - Mrs. A. Desjardins

NBC Defence Division
Director - Dr. P.A. Tate
Nuclear Effects Section - Dr. F.P. Szabo
Radiation Biology Section - Dr. A. Cairnie
Chemical Defence Section - Dr. H.L. McDermot
- Dr. R.A.B. Bannard (Acting)
Materials Section - Mr. J.A. Wheat
Engineering Section - Mr. J.A. Baillot
Environ. Protection Section - Dr. J.A. McAndless

Electrical Power Sources Division
Director - Dr. E.J. Casey
Primary Power Sources Section - Dr. G.D. Nagy/Mr. W.A. Armstrong (Acting)
Rechargeable Systems - Dr. R.M. Hayashi
Vehicle Mobility Section - Mr. I.S. Lindsay
(from Earth Sciences [c])
Entomology Group - Mr. I.S. Lindsay

Defence Electronics Division
Director - O.A. Sandoz (Acting)
Electronic Warfare Section - O.A. Sandoz
Countermeasures Section - Dr. T.W. Tucker
Electronic Warfare Sys. Analysis - Mr. F.W. Symons
Remote Sensing Section - Dr. I.H.S. Henderson
(from Earth Sciences)
Telecommunications Liaison Office - E.A. Thompson

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[a] Title for Head of Laboratory changed from Director-General to Chief.

[b] Defence Industrial Research Office terminated in mid-1976.

[c] Earth Sciences Division disbanded.

1977 - 1978

Defence Research Establishment Ottawa (DREO)

Chief - Mr. C.R. Iverson

Office of Chief
- Scientific Executive Assistant - Mr. H.L. Nash (1977)
  - Dr. H.L. McDermot (1978)
- DREO Library - Ms. D. Hackie
- Photography - Mr. W. Harrington

Director of Administration - Mr. D. Blakely
- Finance - O.P. Chambers
- Supply - K.J. Haley
- Central Registry - Mrs. A. Desjardins

Protective Sciences Division
Director - Dr. P.A. Tate
- Nuclear Effects Section - Dr. F.P. Szabo
- Radiation Biology Section - Dr. A. Cairnie
- Chemical Defence Section - Dr. R.A.B. Bannard
- Materials Section - Mr. J.A. Wheat
- Engineering Section - Mr. J.A. Baillot
- Environmental Protection Section - Dr. J.A. McAndless

Energy Conversion Division[*]
Director - Dr. E.J. Casey
- Chemical Sources Section - Mr. W.A. Armstrong
- Energy Systems Section - Dr. R. Hayashi
- Vehicle Mobility Section - Mr. I.S. Lindsay
- Entomology Gp - Mr. I.S. Lindsay

Defence Electronics Division
Director - Mr. E.A. Thompson (Acting)
- Radar ESM and Countermeasures - Mr. L.G. Rowlandson
- TLO and COMM EW - Mr. E.A. Thompson
- Electromagnetics Section - Mr. K.A. Peebles
- Signal Processing and Display - W.T. MacKenzie
- Remote Sensing - Dr. I.H.S. Henderson
- Radar Countermeasures - Dr. T.W. Tucker
- Systems Analysis - Mr. F.W. Symons

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[*] Formation of Energy Conversion Division from Electrical Power Sources Section.

1979

Defence Research Establishment Ottawa (DREO)

Chief - Mr. C.R. Iverson

Office of the Chief
- Scientific Executive Assistant - Dr. H.L. McDermot
- DREO Library - Vacant
- Photography - Mr. W. Harrington
- Central Registry - Mrs. A. Desjardins

Director of Administration - Mr. R. Desjardins
- Finance - Mr. O.P. Chambers
- Supply - Mr. K.J. Haley

Protective Sciences Division
Director - Dr. P.A. Tate
- Nuclear Effects Section - Dr. F.P. Szabo
- Radiation Biology Section - Dr. A. Cairnie
- Chemical Defence Section - Dr. R.A.B. Bannard
- Environ. Protection Section - Dr. R.M. Crow (acting)
- Materials Section - Mr. J.A. Wheat
- Engineering Section - Mr. J.A. Baillot
- Entomology Gp* - Mr. I.S. Lindsay

Energy Conversion Division
Director - Dr. E.J. Casey
- Chemical Sources Section - Mr. W.A. Armstrong
- Energy Systems Section - Dr. R. Hayashi

Defence Electronics Division
Director - Dr. G.L. Nelms
- Radar ESM & Countermeasures - Mr. L.G. Rowlandson
- Comm EW - Mr. E.A. Thompson
- Radar Electronic Countermeasures - Dr. T.W. Tucker
- Signal Processing and Display - W.T. MacKenzie
- Electromagnetics - Mr. K.A. Peebles
- Remote Sensing - Dr. I.H.S. Henderson
- Telecom. Liaison Office - Mr. R. Abercrombie

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* Entomology Group transferred to Protective Sciences Division.

1980 - 1981

Defence Research Establishment Ottawa (DREO)

Chief - Mr. C.R. Iverson

Deputy Chief - Dr. G.L. Nelms

Office of the Chief
Telecomm. Liaison Office[a] - Mr. A.R. Abercrombie
Scientific Executive Assistant - Dr. H.L. McDermot
DREO Library[b] - Ms. T. Matiisen

Director of Administration - Mr. R.A. Desjardins
Finance - O.P. Chambers
Supply - K.J. Haley

Protective Sciences Division[c]
Director - Dr. P.A. Tate
Chemical Defence - Dr. R.A.B. Bannard/Dr. J.J. Norman
Engineering - Mr. J.A. Baillot
Environmental Protection - Dr. R.M. Crow (acting 1980)
- Dr. L.D. Reed
Materials - Mr. J.A. Wheat
Nuclear Effects - Dr. F.P. Szabo
Radiation Biology - Vacant

Energy Conversion Division
Director - Mr. W.A. Armstrong (Acting)
Chemical Sources - Dr. C.L. Gardner
Energy Systems - Mr. W.A. Armstrong

Electronics Division[d]
Director - Mr. D. McKinnon
Electromagnetics - Mr. K.A. Peebles
Remote Sensing - Dr. I.H.S. Henderson
SARSAT - Mr. R. Hafer

Electronic Warfare Division[d]
Director - Mr. A. Sewards
Comm EW - Mr. R. Inkol (Acting)
Radar Countermeasures - Dr. T.W. Tucker
Radar Elect. Support Meas. - Mr. L.G. Rowlandson
Systems Analysis - Mr. F.W. Symons

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[a] Transfer of Telecommunications Liaison Office from Defence Electronics to Office of the Chief.
[b] Now incorporates photography, illustrations groups.
[c] Termination of Entomology Group.
[d] Formation of Electronics and Electronic Warfare Divisions from Defence Electronics Division.

1982 - 1983

Defence Research Establishment Ottawa (DREO)

Chief - Mr. C.R. Iverson (1983)
- Dr. G.L. Nelms (1983)

Deputy Chief - Dr. G.L. Nelms (1982)
- Mr. W.G. Thistle (1983)

Office of the Chief
    Telecommunications Liaison Office - Mr. A.R. Abercrombie
    Scientific Executive Assistant - Mr. E.E. Criddle
    DREO Library - Ms. T. Matiisen

Director of Administration - Mr. O.P. Chambers (acting)
    Finance - O.P. Chambers
    Supply - K.J. Haley

Protective Sciences Division
Director - Dr. C.E. Clifford
    Chemical Defence - Dr. J.J. Norman
    Sr. Scientist Chemical Defence - Dr. R.A.B. Bannard
    Engineering - Mr. J.A. Baillot
    Environmental Protection - Dr. L.D. Reed
    Materials - Mr. J.A. Wheat
    Nuclear Effects* - Dr. F.P. Szabo

Energy Conversion Division
Director - Mr. W.A. Armstrong (Acting)
    Chemical Sources - Dr. C.L. Gardner
    Energy Systems - Dr. D. Snelling (Acting)

Electronics Division
Director - Mr. D. McKinnon
    Electromagnetics - Dr. P. Bhartia
    SARSAT - Mr. R. Hafer
    Remote Sensing - Dr. B.G. Young (Acting)
    Space Based Radar Surveil. - Mr. R. Hafer (1983)

Electronic Warfare Division
Director - Mr. A. Sewards
    Comm EW - Mr. P. Yansouni (Acting)
    Radar Countermeasures - Dr. T.W. Tucker
    Radar Electr. Support Measures - Mr. L. Rowlandson
    Systems Analysis - Mr. F.W. Symons

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* Nuclear Effects and Radiation Biology Sections amalgamated.

1984 - 1985

Defence Research Establishment Ottawa (DREO)

Chief - Mr. W.G. Thistle (1984) (acting)
- Dr. R.M. Heggie (1985)

Deputy Chief - vacant

Office of the Chief
Telecom. Liaison Office - Mr. A.R. Abercrombie
Scientific Executive Assistant - Mr. E.E. Criddle
DREO Library - Ms. T. Matiisen
PMO DND MSAT - Mr. A.R. Abercrombie (acting)

Director of Administration - Mr. O.P. Chambers
Finance - O.P. Chambers (Acting)
Supply - K.J. Haley
- A. Chartrand
Central Registry -

Protective Sciences Division
Director - Dr. C.E. Clifford
Chemical Defence Section - Dr. J.J. Norman
Sr. Scientist Chemical Defence - Dr. R.A.B. Bannard
Environmental Protection Section - Dr. L.D. Reed
Materials and Engineering Section[a] - Dr. B. Harrison
Nuclear Effects Section - Dr. F.P. Szabo

Energy Conversion Division
Director - Mr. W.A. Armstrong (Acting)
Chemical Sources Section - Dr. C. Gardner
Energy Systems Section - Mr. W.A. Armstrong

Electronics Division[b]
Director - Mr. D. McKinnon
Electromagnetics - Dr. D. Liang (Acting)
EHF Satellite Comm (New) PM - Mr. P. Maltis
Space-Based Radar Surveill. - Mr. R. Hafer

Electronic Warfare Division
Director - Mr. A. Sewards
Comm EW - Dr. F.H. Palmer
Radar Countermeasures - Dr. W. Cornish
Radar Electr. Support Measures - Mr. L. Rowlandson
Systems Analysis - Mr. F.W. Symons
Technical Support - Mr. D. Judd

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[a] Materials Section and Engineering Sections merged.

[b] Remote Sensing Section terminated, SARSAT project completed.

1986

Defence Research Establishment Ottawa (DREO)[a]

Chief - Dr. R.M. Heggie

Deputy Chief - W.A. Armstrong (acting)[b]

Office of the Chief
- Telecomm. Liaison Office - Mr. A.R. Abercrombie
- Publications - M. Ritchie
- H/IS - S. McIntyre (Acting)
- PMO DND MSAT - Mr. R. Abercrombie (acting)
- Scientific Executive Assistant - Mr. E.E. Criddle

Director of Administration - Mr. A. Chartrand (Acting)
- Finance - M. Isaacs
- Supply - A. Chartrand
- Central Registry - N. Olive

Protective Sciences Division
Director - Dr. C.E. Clifford
- Chemical Defence Section - Dr. J.J. Norman
- Sr. Scientist Chemical Defence - Dr. R.A.B. Bannard
- Chemical Protection Section[c] - Dr. B. Harrison
- Environmental Protection Section - Dr. L.D. Reed
- Nuclear Effects Section - Dr. F.P. Szabo

Electronics Division
Director - Mr. D. McKinnon
- Electromagnetics - Dr. D. Liang (Acting)
- EHF Satellite Comm PM - Mr. R. McPherson (acting)
- Space-Based Radar Surveil. - Mr. R. Hafer

Electronic Warfare Division
Director - Mr. A. Sewards
- Comm EW - Dr. F.H. Palmer
- Radar Countermeasures - Dr. W. Cornish
- Radar Electr. Support Measures - Mr. L. Rowlandson
- Systems Analysis - Mr. F.W. Symons
- Technical Consultant - Mr. D. Judd

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[a] Energy Conversion Division terminated.

[b] Position terminated when W.A. Armstrong transferred to CRAD HQ.

[c] Materials and Engineering sections merged to form new Chemical Protection Section.

1987 - 1988

Defence Research Establishment Ottawa (DREO)

Chief - Dr. R.M. Heggie (1987)
- Dr. G.L. Nelms (1988)

Office of the Chief
- Telecom. Liaison Office[a] - Mr. A.R. Abercrombie (1987)
- Library - S. McIntyre (Acting 1987)/(1988)
- Publications - M. Ritchie
- Scientific Executive Officer - Mr. E.E. Criddle

Director of Administration - Ms. J. Pelletier
- Finance - M. Isaacs
- Supply - A. Chartrand
- Central Registry - N. Olive

Director, Program Support (Telecommunications Liaison)[a] - Mr. A.R. Abercrombie (1988) (Acting)

Protective Sciences Division
Director - Dr. C.E. Clifford
- Chemical Detection & Decontamination Section[b] - Dr. J.J. Norman
- Chemical Protection Section - Dr. B. Harrison
- Environmental Protection Section - Dr. B. Farnworth (acting 1987)
  - Dr. R.M. Crow (1988)
- Nuclear Effects Section - Dr. F.P. Szabo

Electronics Division
Director - Dr. J.L. Pearce
- Electromagnetics - Dr. D. Liang
- EHF Satcom - Dr. W.L. MacMillan
- Space-Based Radar - Mr. R. Hafer

Electronics Warfare Division
Director - Mr. A. Sewards
- Comm EW - Dr. F.H. Palmer
- Radar Countermeasures - Dr. W. McRitchie
- Radar Electr. Support Measures - Mr. P. Yansouni
- Systems Analysis - Mr. F.W. Symons
- Technical Consultant - Mr. D. Judd

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[a] Deputy-chief position and Telecommunications Liaison Office merged and renamed as Director, Program Support (Telecommunications Liaison).

[b] Chemical Defence Section renamed Chemical Detection and Decontamination Section.

1989 - 1990

Defence Research Establishment Ottawa (DREO)

Chief - Dr. G.L. Nelms (to mid 1990)
- Dr. J.L. Pearce (after mid-1990)

Scientific Executive Officer - Mr. D. Judd (Acting) (1989)
- Lt(N) H. Krikorian (1990)

Program Support Telecommunications Liaison
Director - Mr. R. Abercrombie (Acting - 1989), Mr. W. Osborne (1990)
- Library - S. McIntyre
- Publications - M. Ritchie
- Central Registry

Director of Administration - Ms. J. Pelletier
- Finance - Mr. M. Isaacs
- Supply - Mr. A. Chartrand
- Computer Services - Mr. M. Gill
- Construction - Ms. J. Ross

Protective Sciences Division[a]
Director - Dr. B. Harrison
- Sr. Scientist, Chemical Defence - Dr. J.J. Norman
- Chemical Protection Section - Dr. J. Bovenkamp
- Environmental Protection Section - Dr. R.M. Crow

Electronics Division
Director - Mr. W. Hindson (Acting)
- Navigation & Integrated Systems - Dr. D. Liang
- PM SBR Surveillance - Mr. R. Hafer
- EHF Satcom - Mr. W. Hindson
- Nuclear Effects Section - Dr. F.P. Szabo

Electronic Warfare Division
Director - Dr. F.H. Palmer (from Aug. 1990)
- Comm EW - Dr. F.H. Palmer (to Aug. 1990)
- Radar Countermeasures - Ms. C. Hutton
- Radar Electr. Support Measures - Mr. P. Yansouni
- Technical Consultant - Mr. D. Judd

Radar Division[b]
Director - Mr. D. Mabey (1990) / Mr. G.J. Marwood (Acting, 1991)
- Surface Radar - Mr. G.J. Marwood
- Airborne Radar - Mr. M.R. Vant
- Space-Based Radar - Mr. A.W. Bridgewater

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[a] Chemical Detection and Decontamination Section transferred to DRES, Nuclear Effects Section transferred to Electronics Division.

[b] Radar Division added, transferred from CRC.

1991 - to date

Defence Research Establishment Ottawa (DREO)

Chief - Dr. J.L. Pearce

Scientific Executive Officer - Ms. M. Capstick

Program Support Telecommunications Liaison
Director - Mr. W. Osborne
- Construction - Ms. J. Ross
- Machine Shop - Mr. W. Dickson
- Library - S. McIntyre
- Publications - M. Ritchie
- Telecommunications Liaison Officer - Mr. M. McKinnon
- Computer Services - Mr. M. Gill
- Central Registry -

Director of Administration - Ms. J. Pelletier
- Finance - Mr. M. Isaacs
- Supply - Mr. K. Fife

Protective Sciences Division
Director - Dr. B. Harrison
- Sr. Scientist, Chemical Defence - Dr. J.J. Norman
- Chemical Protection Section - Dr. J. Bovenkamp
- Environmental Protection Section - Dr. R.M. Crow

Electronics Division
Director - Mr. W. Hindson
- Navigation & Integrated Systems -
- PM SBR Surveillance - Mr. R. Hafer
- EHF Satcom - Mr. W. Hindson
- Nuclear Effects Section - Dr. F.P. Szabo

Electronic Warfare Division
Director - Dr. F.H. Palmer
- Comm EW - Dr. R. Carbonneau
- Radar Countermeasures - Ms. C. (Hutton) Malone
- Radar Electr. Support Measures - Mr. P. Yansouni
- Technical Consultant - Mr. D. Judd

Radar Division
Director - Mr. G.J. Marwood (Acting) / Dr. P. Bhartia
- Surface Radar - Mr. G.J. Marwood
- Airborne Radar - Mr. M.R. Vant
- Space-Based Radar - Mr. A.W. Bridgewater

ANNEX B

ORGANIZATION OF DRTE

1945 - 1967

Compiled by LeRoy Nelms and Jim Norman

1945 Radio Propagation Laboratory

1948 Radio Propagation Laboratories
- Superintendent - F.T. Davies
  - Stormy Weather Group - Dr.R.C. Langille

1950 Defence Research Electronics Laboratory
- Superintendent - F.T. Davies
  - Radio Propagation Laboratory

1951 Defence Research Telecommunications Establishment
- Superintendent - F.T. Davies
  - Radio Physics Laboratory - J.C.W. Scott
  - Electronics Laboratory - J.W. Cox

1955 Defence Research Telecommunications Establishment
- Superintendent - J.C.W. Scott
- Deputy Superintendent - B.A. Walker
- Assistant Superintendent - Dr.R.C. Langille
  - Radio Physics Laboratory - J.C.W. Scott
    - Theoretical Section
    - Atmospheric Physics Section
    - Radio Prediction Section
    - Radio Propagation Sections (3)
  - Electronics Laboratory - J.W. Cox
    - Transistor Section
    - Radio Warfare Section
    - Components Section
    - Navigation Section

1958- 1965 Defence Research Telecommunications Establishment
- Superintendent - J.C.W. Scott
- Deputy Superintendent - B.A. Walker
- Assistant Superintendent - Dr.R.C. Langille
  - Radio Physics Laboratory - J.C.W. Scott
    - Upper Atmospheric Physics Section
    - Ionospheric Section
    - Tropospheric Section
  - Electronics Laboratory - J.W. Cox
    - Transistor Section
    - Radio Warfare Section
    - Components Section
    - Navigation Section
    - Technical Services
- Communications Laboratory - Dr. J.H. Chapman
  - Radar Section
  - Applied Propagation Section
  - Communications Section

1965-1967

Chief Superintendent - F.T. Davies

Deputy Chief Superintendent - J.H. Chapman
Theoretical Research - J.C.W. Scott

Administration Wing - Superintendent - P.J. Lusick

Scientific Editor - P.A. Field

Scientific Staff Officer - A.W. Adey (1965-66), C.V. Rayment (1967)
    Library - M.G. Garland

Electronics Laboratory - Superintendent - R.C. Langille
    Computing Centre -G.T. Lake (left 1966)
    Space Electronics Section - C.A. Franklin
    Basic Circuits Section - C.D. Florida
    Space Mechanics Section - J. Mar
    Solid State Physics Section - J.N. Barry
    Technical Services Section - D.P. Hoyt

Communications Laboratory - Superintendent - J.H. Meek
    Communications Systems Section - W.L. Hatton
    Satellite Communications Section - R.M. Dohoo
    Detection Systems Section - D.R. Hansen
    Signal and Data Processing Consulting - F.E. Smith (1967)
    Prince Albert Radar Laboratory - E.A. Seaman
    Applied Communication Section (1967) - D.R. Caskill

Radio Physics Laboratory - Superintendent - I. Paghis
    High Frequency Section - E.S. Warren
    Low Frequency Section - J.S. Belrose
    Plasma Physics Section - R.E. Barrington
    Rocket Section - D.L. Matthews (Section gone in 1966)

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